COCONUT RESEARCH BOARD

COCONUT RESEARCH INSTITUTE OF SRI LANKA

REPORT FOR 2004

COCONUT RESEARCH INSTITUTE - REPORT FOR 2004

COCONUT RESEARCH BOARD

REPORT OF THE
COCONUT RESEARCH INSTITUTE
FOR 2004

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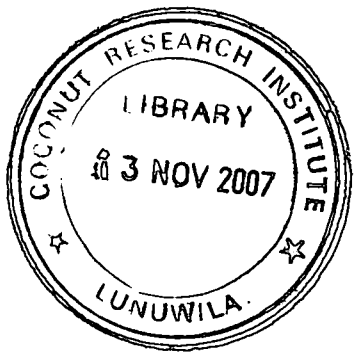

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CONTENTS

COCONUT RESEARCH INSTITUTE OF SRI LANKA

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A Jayathilake

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A R A N Kumara

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C S Herath, B.Sc. (Agric)

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J K J P Jayawardena, B.Sc. (Agric)

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W G L Rodrigo

Senior Clerk/Typist

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Mrs. K A P Chandani

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H P Asoka Kumara

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A I F Fernando

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Dip. (Purchasing & Material Management)

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Chief Clerk

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Mrs. H M W S Athauda

Senior Telephone Operator

I H Nelson

Stenographers (English)

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Supplies Assistant

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M A D M F Appuhamy

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Dip. in Accountancy

Senior Internal Audit Clerk

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Senior Typist (English)

Mrs. W J M D M A Fernando

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Accounts Clerk

S A D Richard

Senior Book Keeper

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S M Sirisoma
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Clerk/Typist

M Somasiri

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M B Upali Wijetunga

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Dip (Eng. Science)

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Foreman (Electrical)

D W J Jayakody

Foreman (Mechanical)

R Vithanage

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Senior Clerk/Typist

Mrs. N R Ayagama
K T J N W Perera

Senior Motor Mechanic

R M S G Ratnayake

Senior Mason

W M Dhanapala

Senior Carpenter

A A K Amarasinghe

Linesman

R S P Jayamanne

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

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W P R R Fernando

Clerk/Typist

W A L R Feranando

Bandirippuwa Estate

Superintendent

Mr. G B A Wijesekare

Field Officer

G P N Chandrasiri

Supervisor

S Alahakoon

Senior Supervisor

M P W Fernando
A G B G Silva

Ratmalagara Estate

Superintendent

A N Eknaligoda

Senior Supervisor

T M Keerthiratne

Isolated Seed Garden

Superintendent

U W B A Weragoda, B. Sc. (Agric)

Clerk/Typist

H M Podiratne

Senior Supervisor

Piyal Ranjith Fernando

Lab/Field Assistant

H A P B Fernando

Supervisor

A Sugathadasa

Maduruoya Seed Garden

Superintendent

W M U Ratnayaka

Lab/Field Assistant

M G D Placidez

Supervisor

M A S Fernando
W M D R Wijesinghe

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Officer-in-charge	*Superintendent*
N Gamage	D P S K Hettiarachchi, Dip (Agric. & EM)

Walpita Estate

Officer-in-charge

W A H Upali

Pottukulama Research Station

Officer-in-charge	*Clerk/Typist*
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Supervisor

W M N G Wijethunga

Makandura Seed Garden

Superintendent	*Senior Lab/Field Assistant*
I A N Hemasiri	M Victor

Supervisors

A P C Pradeep, Dip. (Agric)

Pallama Seed Garden

Superintendent	*Senior Clerk/Typist*
W S M A Fernando	J A R Reginold

** **On study Leave**
*** **On Overseas No-pay leave**
**** **Sabbatical Leave**

THE COCONUT RESEARCH INSTITUTE
LUNUWILA

The Board and Institute

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

Mission of the CRI

Our Mission is through Innovative Research and Development:

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

Functions of the Institute

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

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

Coconut Research Board

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

The members of the Board upto June 2004

Dr S S B D G Jayawardene	- Chairman
Dr D Kirtisinghe	- Member
Mr C D V Aponso	- Member
Mr R Fernandopulle	- Member
Mr A Hettiarachchy	- Member
Mrs I Sugathadasa	- Member
Dr R H S Samaratunga	- Member
M Lincoln Fernando	- Observer Member / Chairman CCB
Mr H A Tillekeratne	- Observer Member / Chairman CRI

The members of the Board after June 2004

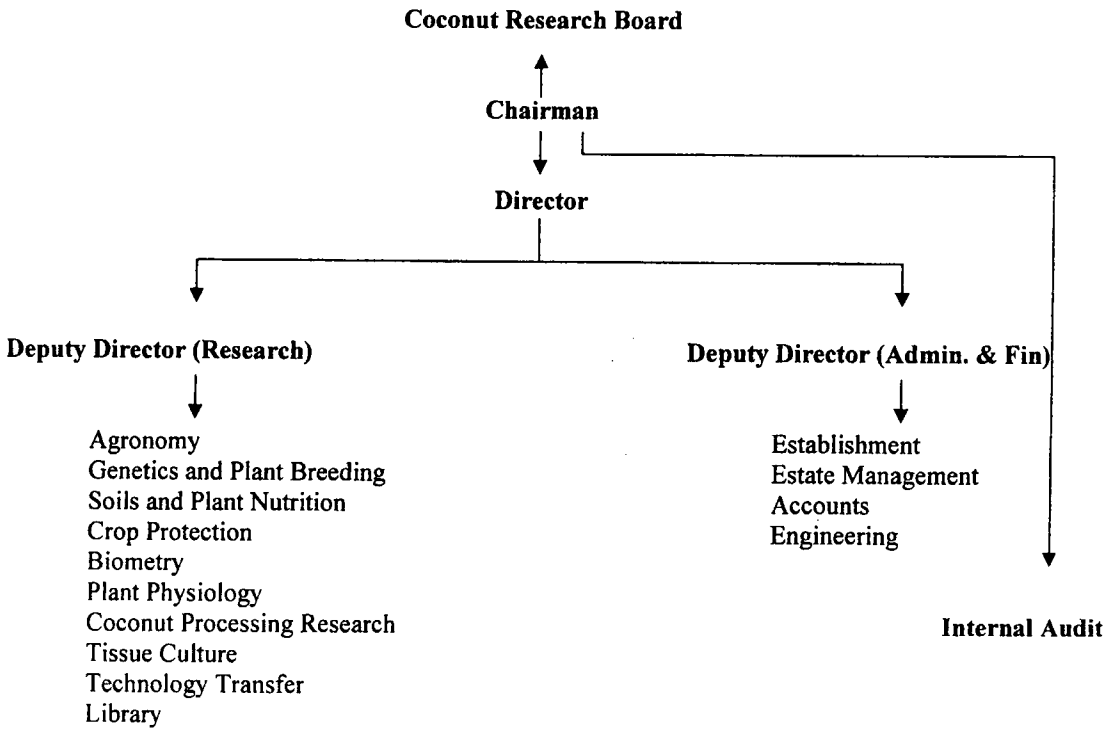
Dr D B T Wijeratne	- Chairman
Mr S Wirasinghe	- Member
Mr Abeygunasekera	- Member
Mrs Chandrika V Ethugala	- Member
Mr Indika Jayatilleke	- Member
Mrs D R M S K Rajapakse	- Member
*Mrs N Wijekoon	- Member
*Mr R M Gunawardena	- Member

*Appointed to the Board in December, 2004

Management

The Chairman is the Chief Executive Officer of the Institute. The Administrative Head of the Institute is the Director who is responsible for the direction and supervision of all research and administrative functions of the Institute, and the implementation of all policies and programs lay down by the Board.

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

Funding

As a public sector organization, CRI is primarily dependent on government funding (Consolidated Fund). Limited amount of funding for research is received from outside donor agencies and as competitive research grants from Council for Agriculture Research Policy. Inadequacy of recurrent funds to meet escalating cost of contractual services such as electricity, fuel, and telephone charges has negative influence on research and maintenance activities of the Institute. All the Research sub-stations and Genetic Resources Centers of the Institute are being maintained as self-financed units with effect from 1st January 2004. Gross income and expenditure of sub-stations are given in figure 1. Government funding for CRI as capital and recurrent expenditure for the last four years with the current year are given in figure 2.

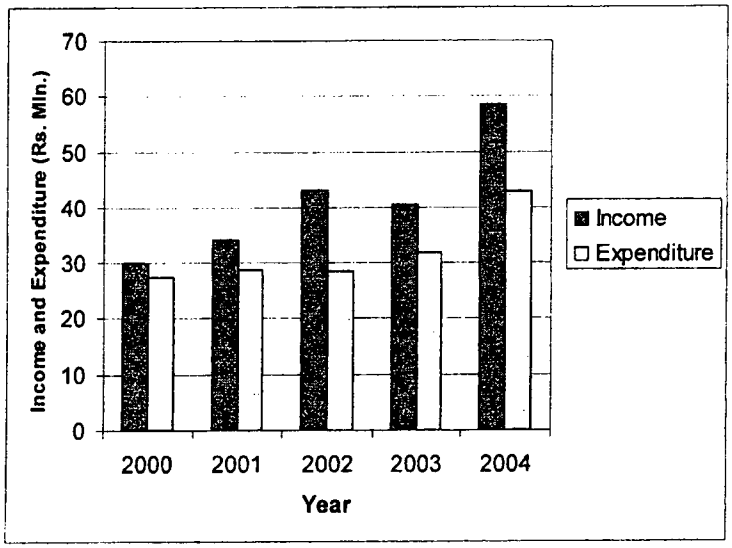


Figure 01: *Gross income and expenditure of research sub-stations*

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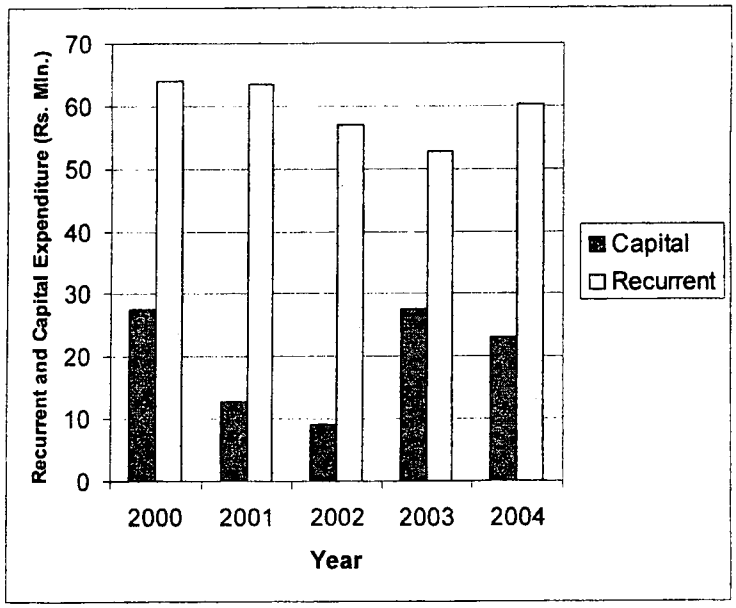

Figure 2 : *Government funding as recurrent and capital expenditure*

The coconut CESS fund also provides substantial contribution for special projects in situations where adequate funding is not available from government. The total investment from the CESS fund and number of projects assisted for the past four years with current year are given below.

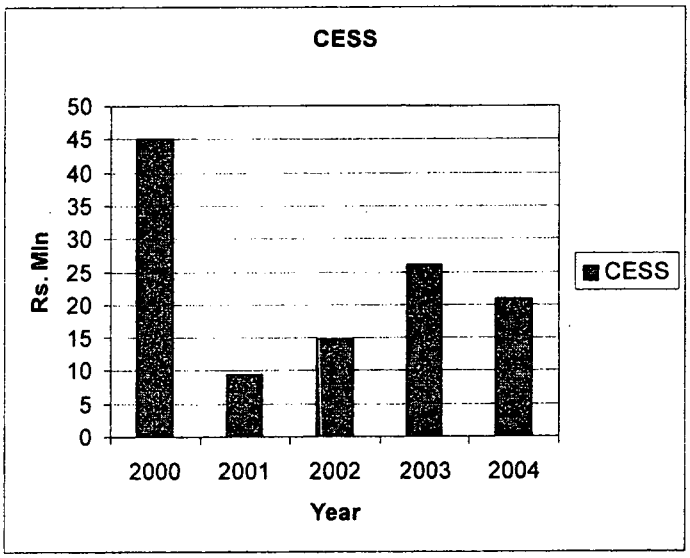

Figure 03: *CESS funds*

In addition to these funding, scientists at the CRI annually attracts funding from various local and foreign funding sources as given below for the special projects.

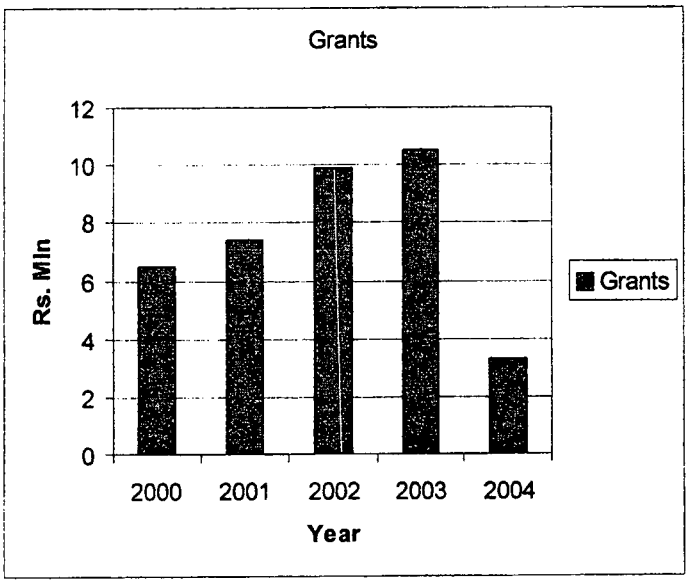

Figure 4: *Funds received from various sources*

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

1. GENERAL

Year 2004 was a special year for the Coconut Research Institute as it completed 75 years of service to the industry, having established as the Coconut Research Scheme on 29 April 1929. The Institute marked this occasion by organizing religious ceremonies - overnight Pirith Chanting followed by an alms giving for 75 monks, Catholic mass, and Muslim religious observances, on the 30 April 2004. An International Coconut Conference on the theme "Tree of Life-New Trends in the Millennium" was held with an exhibition on value added products, concurrently from 9-11 September 2004. Many coconut-producing countries attended this meeting. This conference gave an excellent opportunity to display very distinctive and dynamic role in the Institute played by making many advances in respect of coconut research, recommendations to the coconut industry over the past three decades or more and to highlight advances in on going research activities. Further, it provided us a platform to boost the image of the institute locally and internationally and to attain international recognition.

Annual coconut production is considered, first part of the year recorded a very good crop, however from the fourth crop onwards production declined sharply recording 30-50% reduction in crop yield and size of the nuts in many parts of the island due to the drought conditions prevailed in two consecutive years. The predicted national coconut production by the Institute was 2900 million nuts for 2004 and approximate national coconut production calculated at 2600 million nuts was 11% decline compared to the expected yield, but almost similar to the actual coconut yield of the previous year. Dry weather conditions prevailed towards latter part of 2003 and failure of South- West monsoon rains in the early part of 2004 has contributed to this situation. However, from April 2004 onwards many coconut-growing areas experienced evenly distributed good rainfall. It is expected that favourable weather conditions may improve coconut production in 2005. However, lag effect of severe drought that prevailed in 2003 may continue to reflect in 2005 also, in so far as initiation of the inflorescence to development of mature nuts, it takes approximately three years.

The average price of coconuts increased sharply in urban areas recording Rs.20.00 to Rs.25.00 per nut towards the fourth quarter of the year, owing to the short supply of nuts in almost all coconut growing areas. The Coconut Cultivation Board and the Coconut Research Institute intervened immediately to ease the short supply of coconuts in urban areas and unscrupulous escalation of prices by providing fresh nuts from their estates, to consumers in urban areas at a cost of Rs.13.50. The Coconut Cultivation Board distributed coconuts within Colombo city and suburbs, and also through public sector organizations. The government took a major policy decision this year by imposing Rs. 3.00 import CESS for each kg of imported vegetable oils. This decision will help to increase CESS collection from 2005 onwards. This money will be ploughed back for the development activities of the coconut sector.

The Institute received Rs.81 million and Rs.26 million from the Consolidated fund as recurrent and capital expenditure respectively. This allocation of recurrent budget had 25 million short fall compared to the amount requested under recurrent budget. Due to escalation of electricity, fuel and telephone charges as well as other maintenance expenditure, Institute had to curtail some activities to manage with allocated recurrent funds. In the last quarter Rs.10 million was obtain from the CESS reserved fund to settle outstanding payments of the Institute. From the Coconut CESS fund institute received Rs.43 million for various development projects including Rs.7 million for the renovation of staff quarters and other buildings as government grant was not sufficient to increase maintenance budget of the institute buildings.

Technology Transfer Division strengthened its activities by using print and electronic media to transfer new technologies and recommendations to the extension staff as well as growers. Several video documentaries related to coconut mite control, irrigation and intercropping in coconut lands were produced as mass communication tools and they were telecast at several occasions in national TV. The division took another important step by producing several CDs to carry important advisory messages for resourceful growers. CRI participated in field days organized by the coconut cultivation Board.

Research Highlights

While continuing the research program according to the corporate plan of the institute, special efforts were made to develop integrated pest management strategy for coconut mite. The Institute paid highest priority for coconut mite control program by providing necessary assistance to the coconut growers through Coconut Cultivation Board. The Coconut Cultivation Board paid pivotal role by engaging their extension staff in mite control activities especially in boundary areas. Sporadic occurrence of coconut mite was reported from the district of Hambanthota, Kalutara, Monaragala, Ampara, Rathnapura, and Matale Districts. Application of 30% used engine oil with soap mixture on nuts of infested palms was recommended as an interim recommendation as it gave 100 percent mortality of mites resulting in discontinuation of scars. The application of this mixture at bi-monthly intervals to the newly developing untreated nuts is necessary until the damage is reduced to a minimal level. Main draw back of this recommendation is that trained climbers are to be used to apply used engine oil on to developing bunches, time and heavy cost involve for large estates. Research program developed to envisage the use of biological agents to control coconut mite continued with satisfactory progress. A natural predator of coconut mite *Neoseules bakari* was bred in the laboratory in large quantities and released to an infested area at two occasions. Another coconut mite eating mite species imported from Brazil and behavior of the mite under local conditions is investigating. Ten different strains of *Haustella thomsonii*, an entomopathogenic fungus was isolated from local environment. Out of them 4 strains are found to be more promising. CABI Bioscience, UK is now working on this fungus to develop a commercial product.

The new coconut hybrid between Dwarf Green x San Ramon, first released on 09 September 2004 under the name "Kapruwana". This is the most promising hybrid released so far. Cultivar evaluation trials conducted with this hybrid has shown 11.5% more copra production and an average yield of more than 100 nuts.

The Genetics and Plant Breeding Division achieved another expected goal by exchanging germplasm with Ivory Coast, a long awaited activity. Ten coconut varieties were obtained including five pacific varieties from Ivory Coast. This germplasm exchange program will help us to enhance genetic diversity of coconut and to expand breeding program in the future to meet needs of the industry.

The Coconut Processing Research Division focused it activities mainly to develop value added products out of coconut kernel. Value added virgin coconut oil based products, Coconut skim milk beverage, mayonnaise from virgin coconut oil, coconut jam from tender kernel, coconut vinegar out of seasoned coconut water are some of the products developed during the year. Some of these technologies were transferred to rural communities through ADB funded "Poverty Alleviation Project". Technology developed for the production of coconut paste for culinary preparations was commercialized. Popularization of coconut paste would help to save 30% domestic wastage of coconuts making them available for other industries.

CRI recommended cultivation of gliricidia in coconut lands for bio-energy production. Mixing of 50 kg of gliricidia leaves into the soil within the manure circle, supplements entire requirement of urea fertilizer, and saving Rs.29.70 per palm for chemical fertilizers. Gliricidia wood (chips) at 20% moisture could be sold at a price of Rs.2.00 per kilo gaining additional income of Rs.15,000 per hectare from 3rd year of planting onwards. One hectare of coconut land will produce

5.4 metric tons of wood and 4.5 metric tons of foliage annually. Gliricidia wood chips are being used for gasifiers to generate dendrothermal energy.

After many years of negotiations, Department of Agriculture leased out an extent of 75 acres from the Middeniya Farm for a 30-year period. Activities are underway to establish a research substation in the Southern Province in this land.

With the change of Government Makandura seed garden, which was taken over by the Board of Investment, Wayamba Province, again handed back to the institute.

Research projects funded by foreign agencies such as Coconut Genetic Resources Network (COGENT), Second Perennial Crop Development Project funded by ADB, Poverty Alleviation Project funded by ADB and International Fund for Agricultural Research and Development (IFAD) continued with satisfactory progress. These two ADB funded Projects were completed towards the end of the year.

With the approval of the Director General, Public Enterprises Division, research budget of the applied research divisions was capitalized from 2003. Research expenditure of Tissue culture, Plant Physiology and Biometry divisions was allocated from the recurrent budget. Utilization of research budget in almost all the divisions were in the range of 85–95 per cent excluding Processing Research Division. Copra curing experiments planed in the newly designed copra kiln were not conducted due to unexpected delays in the construction of the kiln, and short supply of grated coconut from DC mills for coconut virgin oil based experiments were the main reasons for under utilization of funds in the Processing Research Division.

2. ACHIEVEMENTS AND HIGHLIGHTS OF RESEARCH DIVISIONS

2.1 Agronomy

Research program on development of improved agronomic practices for increasing coconut production, increase productivity of coconut lands through intercropping animal husbandry, fuel wood farming and studies on economic policy related issues were continued:

The data received from census and Statistics Department on the latest Agriculture Census survey carried out in 2002 analyzed employing simple percentage calculations and the results revealed the followings:

- The total land area under coconuts in Sri Lanka was 416253 ha in 1982, which has reduced to 394836 ha in 2002, representing a 5% (21417 ha) reduction. The equivalent annual rate of coconut land loss is therefore 1071 ha/2645 ac The coconut land area lost and gained during the two decades were 49 210 ha and 27793 ha respectively

- In 1982, Gampaha district was the second largest coconut district in terms of land area under coconuts, but in 2002 this district has shifted to the third place because of rapid loosing of coconut lands due to fragmentation

- Among the 24 districts[1], 11 districts namely, Gampaha, Kegalle, Colombo, Kalutara, Mannar, Puttalam, Kurunegala, Galle, Kandy, Jaffna and Batticaloa were net loosers of coconut lands while the remaining 13 districts i.e. Badulla, Moneragala, Polonnaruwa, Vauniya, Matale, Hambantota, Matara, Ratnapura, Anuradhapura, Nuwara Eliya, Trincomalee, Ampara and Mulativu were net gainers

[1] Although, Jaffna district has been separated into two districts, as Jaffna & Klinochchi, we considered these two as a one district for the comparison because they were not separated in 1982.

- The biggest looser of coconut lands was Kurunegala district (15536 ha), followed by Gampaha (13919 ha) and Puttalam (5693 ha). The smallest looser was Mannar (271 ha). The biggest net gainer was Anuradhapura (8407 ha)

- Land area under coconuts both in smallholders as well as estate sector has simultaneously increased in Anuradhapura, Moneragala Polonnaruwa and Nuwara Eliya districts

These findings suggest that some districts have lost coconut lands while some districts have newly planted coconuts although the former area is bigger than the latter, resulting in a net loss of coconut area in the country. Therefore, this would negatively affect the national coconut production and hence a strategic approach to hit the 3 billion national annual coconut production in the short run would potentially include:

a) Minimizing, not complete seizure, the fragmentation of high potential coconut lands
b) Expansion of coconuts into non-traditional areas as much as possible
c) Increase the coconut production in lands which currently provide a less than optimal production
d) Launching a rigorous home garden coconut cultivation programme

Application of Glyposate 4 lit/ha (before nut germination) + Dioron at 3.2 kg/ha (after nut germination) found to be effective in controlling weeds in coconut nurseries and this practice saves Rs 1 400.00 for 1 000 coconut seedlings compared to manual weed control. Moreover, Glyposate 4.0 lit/ha and cover cropping treatments were economically effective on controlling weeds in mature coconut plantations, compared to slashing and cattle grazing.

The CARP funded project on "Development of Vermi-composting system in coconut plantations" showed that the promising potential of adapting this technology to recycle waste biomass in coconut lands. Waste biomass can be converted to compost within 4-5 weeks with the mediation of worms. Application of vermi-compost and vermi-extract enhanced the growth of coconut seedlings. This technology is going to be introduced to the CRI estates.

The contribution of two specific coconut-based income-generating cottage activities, namely bract handicraft making and coir yarn spinning to the food security of women has been assessed in two selected rural poor communities, viz Wilpotha and Dodanduwa. Results revealed that only the women of 18-30 years age category get sufficient daily energy intake whereas the daily energy intake of the >30 years age women category is less than the recommended level by WHO. The women's daily caloric intake is significantly and positively associated with their daily income while the daily income is significantly and positively influenced by the level of bract handicraft and coir yarn spinning activities. So, the study concluded that coconut-based cottage-level income generation activities such as bract handicraft making and coir yarn spinning would be a promising source of income of the rural poor, which in turn would improve the food security of the rural women.

The project on "Poverty reduction in Coconut based Rural Communities in Sri Lanka" was implemented in three locations in Sri Lanka with the objectives of enhancing the income of resource poor coconut-based rural communities through sustainable coconut-based interventions; specifically, through the production of coconut high value products, intercropping & livestock farming. The implementation of project activities were done through the community based organizations i.e. TEDS (*Ththtiripitigama* Entrepreneurship Development Society),WSE (Women's Savings Effort) and DWC (*Dodanduwa* Women's Collective). The membership of these three CBOs are 420, 200 and 160 respectively in DWC, WSE & TEDS. Marketable products, that can generate the income for these communities were identified from Market surveys in the respective communities. Thereafter trainings were arranged accordingly. To date 1006 men and women were trained of whom more than 75% are women. Trainings include, leadership building, micro financing, entrepreneurship, coconut high value products, intercropping and livestock farming, coconut nursery management etc. In order to enhance the access to the borrowing capital for investments, which had been identified as a limitation

for income generation through cottage industries, micro credit systems were introduced for three communities through CBOs. The three communities, TEDS WSE and DWC were engaged in the production of coconut based high value products such as coco shell handicrafts, fiber (yarns, doormat, Brushes), ekel (Brooms), kernel (virgin oil, white copra sweets, crude oil, soap), coconut water (venigar), sap (Treacle), bract handicrafts under the patronage of the "Poverty Reduction Project".

In addition, the introduction of coconut based livestock systems (Poultry, quills, Goat, Cattle) and intercropping have also generated income. Poultry has been identified as the most effective livestock intervention to generate income; hence three incubators have been installed in three communities to loan out chicks among farmers. Production of value added milk products has shown promising progress Thuththiripitigama community.

Marketing campaigns were launched to open market avenues for the communities, with the help of NGOs (Voluntary Services Overseas- VSO , *Siyath*). Two fair trade organizations (i.e. NGOs : Siyath Foundation and Gospel House) assisted the marketing of products in the foreign markets. Two communities were able to secure regular export orders for products such as doormats and coconut shell handicrafts. Training on designing, pricing and marketing of coconut-based handicrafts has been conducted. Baseline survey conducted to ascertain the impact of project interventions on showed that income generated by the respondents has significantly improved after the project. Having impressed from the income earned from different activities, most of the members who started in small scale, are expanding their enterprises.

The physical performance and the functional structure of the existing coconut marketing system of fresh coconuts, desiccated coconut and copra were assessed in three major coconut-growing districts, viz. Kurunegala, Puttalam and Gampaha. A majority of the smallholders sells their coconuts through middlemen creating lengthy channels, whereas the majority of estate owners practice either direct selling to desiccated coconut/copra mills or direct selling to brokers while forward contracts were not found at all. There have been 1-2 to 8-10 number of middlemen in the marketing channel. The middle dealers (e.g. primary collectors, middle-level collectors, brokers, wholesalers, retailers and exporters) were found to be the key players in the marketing channel involved in handling, delivering and distributing coconuts into the marketing system. The average transport and handling cost for middle dealers varies from Rs.0.25 to Rs.0.40 per nut. Desiccated coconut and copra prices found to be the major determinants of farm gate price of fresh coconuts. All the intermediaries in the channel extract more than Rs.0.5 per nut at each level and this was Rs.2.00 with respect to the retailer. It was found that the coconut grower gets about 67% of the consumer price for a coconut she/he sells into the system while 33% or 1/3 of the consumer price of a coconut is distributed among the middlemen involved in the system. The regional coconut auctions may be recommended as corrective measures to shorten the marketing channels by reducing the number of intermediaries involved in the marketing system, thereby benefiting the two tail-enders of the channel, i.e. the grower and the consumer. The other approach would be to popularize forward contracts among marketing agents of the system.

2.2 Genetics and Plant Breeding

The most significant event of the Genetics and Plant Breeding Division in the year 2004 was the release of Kapruwana, the new coconut cultivar derived from the cross between *Dwarf Green* x *San Ramon*. Granting registration for 18 private coconut nurseries collaboratively with the Seed Certification Service of the Department of Agriculture, enrichment of coconut germplasm by addition of ten exotic coconut varieties from Ivory Coast, progress made in establishing a mapping population for coconut, establishing a field trial to evaluate the cross, *Dwarf Brown* x *Tall* are other noteworthy accomplishments during the year. The on going long term experiments, genetic evaluation of existing cultivars, progenies and germplasm crosses, establishment of new cultivars in farmer's fields and maintenance of the gene banks were also continued successfully during the year.

Kapruwana, originated from the cross between *Sri Lanka Dwarf Green* and the *Philippine Tall San Ramon* was released as a new cultivar after testing over a period of 18 years by the CRI at the Daisy Valley Estate Mawathagama. Early flowering and high yielding traits of *Dwarf Green* and large nuts, high kernel or meat content or copra content and less susceptibility to moisture stress traits in *San Ramon* were precisely blended in this new cultivar. 'Kapruwana' has exhibited its potential to flower in 4-5 years, bear in 5-6 years and reach yield stability in 10 years after planting with an yield potential of 12,000 nuts per ha. Nuts on average weigh above 1.8 kg with a copra turn over of 300 grams per nut or 3.75 Mt/ha. This is comparable with all the best coconut hybrids developed so far in the world. Most prominent feature of 'Kapruwana' is its ability to withstand drought. 'Kapruwana' has presumably mingled all the best qualities of coconut to qualify as an outstanding coconut hybrid to meet the requirements of both small and large scale growers of coconut in Sri Lanka.

CRI for the first time in the history granted permission for establishment of private nurseries for production of coconut seedlings. Registrations were granted on an agreement signed by CRI and the nursery owner that seedlings should only be raised from seeds provided by CRI and obtain certification for every seedling disposed from the Seed Certification Service of the Department of Agriculture. Among 22 requests received 18 [(Kurunegala 06), Puttalam (07), Matara (01), Matale (01), Polnnnaruwa (01), Anuradhapura (01) and Vauniya (01)] were granted registration.

Enrichment of the coconut germplasm by exotic introductions was further accomplished by collecting 242 embryos of Polynesia Tall, 212 embryos of Tagnanan Tall, 257 embryos of Vanuatu Tall, 42 embryos of Tacunan Green Dwarf, 292 embryos of Tahitian Tall, 351 embryos of Newlekha Green Dwarf, 65 embryos of Tenga Tall, 199 embryos of Malayan Red Dwarf, 276 embryos of West African Tall and 106 embryos of Catigan Green Dwarf. These embryos are now being raised in the Tissue Culture Laboratory of CRI.

Mapping of the coconut genome was envisaged as means of coconut improvement by marker assisted selection. As a pre-requisite towards mapping the genome a pollination programme was initiated for developing a segregating population of coconut using 33 Dwarf Red coconut palms and a single Sri Lanka Tall palm at Bandirippuwa Estate, Lunuwila. This pollination programme was initiated in March 2004. Successful progress was achieved to date with setting of 963 female flowers into immature nuts. Initial framework map is due to be constructed from these and subsequent mapping of QTLs is expected subsequently, by the establishment of these families in the field.

Field evaluation of a new hybrid, *Sri Lanka Dwarf Brown* x *Sri Lanka Tall* was initiated during the year by establishing a field experiment at Raddegoda Estate, Delwita. This experiment was designed as a multilocational trial with the inclusion of the reciprocal of the same cross, *Dwarf Brown* x *San Ramon* and CRIC60, CRIC65 and CRISL98 as controls. Another block at Ratmalagara Estate, Madampe was identified for establishing the second site.

The long-term experiments on genetic evaluation of existing cultivars were continued successfully. In the cultivar evaluation trial inter-varietal hybrids again continued to out perform pure tall cultivars in the two sites, Bandirippuwa (BE) and Suriyapura (SE). The hybrid, *Dwarf Green x Tall* recorded a yield of 12,200 nuts/ha during the year at BE. The respective yields of *Dwarf Yellow x Tall*, CRIC60, Moorock and Plus Palm were 11,200, 10,000, 8600 and 9400 at the same site. At SE the respective yields of the five cultivars were 13,000, 12,000, 8,000, 8400 and 8,000.

The evaluation of progenies arising from *Tall x Tall, Tall x Dwarf Green* and *Tall x San Ramon* at Bandirippuwa and Ratmalagara sites were continued and yields were recorded. The performance of *Tall x Dwarf Green* was once again the best with an annual yield of 11,200 nuts/ha during the year at BE. The corresponding yields of *Tall x Tall* and *Tall x San Ramon* were 10,600 and 10,000 respectively. Performance of all the three progenies at the Ratmalagara site were better where Tall x Dwarf Green recorded 14,400 nuts/ha while *Tall x San Ramon* and *Tall x Tall* recorded 12,400 and 12,600 nuts/ha/yr respectively.

In the progeny experiment at Daisy Valley Estate, Mawathagama the performance of Dwarf Green *x San Ramon* yet again equaled *Tall x Dwarf Green* in copra productivity. Among the reciprocal crosses *Tall x Dwarf* performed better comparing to Dwarf x Tall both in terms of nut production and copra productivity. *Tall x Dwarf Green* was the best with 13,800 nuts/ha (2.98 Copra Mt/ha) followed by *Dwarf Green x Tall* (12,600 nuts/ha and 2.62 Copra Mt/ha), *Dwarf green x San Ramon* (11,800 nuts/ha and 3.02 Copra Mt/ha), *Tall x San Ramon* (9,600 nuts/ha and 2.78 Copra Mt/ha) and *Tall x Tall* (9,600 nuts/ha and 2.23 Copra Mt/ha).

Establishment of CRISL98 (*Tall x San Ramon*) in farmer's fields was continued during the year and 8157 seeds were produced by hand pollination and 2805 seedlings were issued to 20 growers in six districts, Puttalam (7), Kurunegala (5), Gampaha (4), Polonnaruwa (2), Matale (1) and Vavuniya (1). Similar program was commenced to establish the new release, Kapruwana in farmer's fields. During the year 1,166 seeds were produced by hand pollination and 478 seedlings were issued to three growers in Kurunegala (2) and Puttalam Districts.

Conservation of coconut germplasm was continued by maintaining the field gene banks satisfactorily. A new collection was made from Rumassala for conservation as an accession. A total of 26 palms have been identified from the Unawatuna area for in depth investigation and conservation. These are Ran Pol (3), Nawasi (3), Juwan (12), Juwan small (1), Thatin (1), Bothal Thembili (1), Rath Gon Thembili (1), Dothalu (1) and Plus Palms (3). Increasing the production of CRIC65 for high input coconut farming and home garden planting was recognized and a program was initiated to upgrade Genetic Resources Center at Ambakelle to increase the production of CRIC65. Establishment of a drip irrigation facility for mother (dwarf) palms and converting another tall field into a mixed field is now in progress with the assistance of the CESS fund.

2.3 Soils and Plant Nutrition

The Division continued with eleven on-going field experiments. Two new field experiments and one pot experiment were commenced. The deep ground water survey, in the Kurunegala District carried out under Cess Fund was completed. The total research expenditure for research and maintenance was Rs.2,210,000/- and Rs.260,000/- respectively.

The experiment on site specific fertilizer recommendation at Mangala Eliya (S_2, DL_3), showed 34% increase in nut yield from the palms receiving 1400g of urea, 1050g of Imported Rock Phosphate, 2800g of Muriate of Potash and 1750g of Dolomite (Treatment 4) over the control (no fertilizer). Where as 15% increase in nut yield was observed in the palms receiving recommended dose of fertilizer compared to the control. The difference in yield of treated and control palms were statistically significant at 1% level ($p \leq 0.01$). This year (i.e. four years after fertilizer application), increase in nut yield was shown particularly at the site where experiment was located in the soil type classified as Borupan series soils in the Dry Zone. The treatment received additional 600g of urea, 450g of Imported Rock Phosphate, 1200g of Muriate of Potash, and 750g of dolomite (T_4) has shown the highest nut yield compared to the recommended dose (T_2). The site at Kobeigane (S_3, IL_1, Wariyapola series) the palms have shown significant increase in female flower production compared to the palms receiving same treatment at Mangala Eliya. While the palms at Mangala Eliya (T_4) site gave the highest nut yield significant at 5% level($p \leq 0.05$).

Drip irrigation experiment conducted at Rathmalagara Estate showed 34% increase in yield compared to the control (no irrigation). Amongst the treatments this increase was observed with the treatment receiving 40 l/palm/day at 6 days intervals and 250g of APM and 83g of dolomite at monthly intervals per year.

Experiment on comparison of organic and green manure with supplementary application of inorganic fertilizer (APM), showed that the nut yield of palms receiving poultry manure was increased by 38% compared to that of the control (no fertilizer). The yield increase by inorganic fertilizer

application along, over the control (no fertilizer) was 17%. Among other organic sources, cattle manure, goat manure, and gliricidia recorded yield increases of 26%, 21%, and 18% respectively over the control. Sixteen percent yield increase was observed with palms receiving poultry manure over inorganic fertilizers (APM). These results indicate that the application of organic manures such as poultry manure, cattle mature, goat manure as alternative sources for inorganic fertilizer is more economical and have other benefits than that of inorganic fertilizers.

Evaluation of sodium chloride as a substitute for potassium chloride (muriate of potash) revealed that , the yield of potassium chloride treatment was higher than that of sodium chloride, although the difference was not statistically significant. Therefore, it is too early to draw a recommendation from this experiment. The yield difference between potassium chloride and sodium chloride treatments were 14 nuts/palm/year. It was further observed that yield difference of 15 nuts/palm/year and 1 nut/palm/year for the potassium chloride and control (no fertilizer) and sodium chloride and control (no fertilizer) respectively. Leaf nutrients of K, Na and Cl have shown significant difference ($p \leq 0.05$) among the treatments.

The experiment on evaluation of the efficiency of different sources of rock phosphates as a fertilizer for coconut growing soils in the Dry Zone revealed that the mean values of P availability was in the order of Triple Super Phosphate (TSP)> Imported Rock Phosphate (IRP) > High Grade Eppawela Rock Phosphate (HERP) > Eppawela Rock Phosphate (ERP) as determined at monthly intervals up to one year. This study clearly showed that IRP is better than HERP or ERP, for the coconut plantations in the Dry Zone.

2.4 Crop Protection

The research on coconut mite received the highest priority of the Division. Application of a 30% mixture of used engine oil at 2-monthly intervals was recommended to manage the pest especially, in boundary areas of infestations and in home gardens. The research on the development of an integrated management program for coconut mite mainly focused on biological and chemical control methods. It was found that *Neosiulus baraki* (previously referred to as *Neoseiulus* aff. *paspalivorus*) could be mass bred using the flour mite, *Tyrophagus putriscentiae* on laboratory arenas. A single female predatory mite gave rise to 24 motile stages and eggs in 3 weeks when bred on a closed arena without a water barrier. The maximum average fecundity of *N. baraki* (25 eggs) was obtained at 25°C. A life-time fecundity of 143±9.7 eggs was obtained when *T. putresentiae* was fed on rice bran. The daily oviposition rate on rice bran was higher than that of pollen of *Typha* sp. Mass breeding of *N. baraki* for field studies commenced. It was determined that coconut mite could be bred on 3-5 month old embryo-cultured seedlings. Also, *N. baraki* could be bred on the coconut mites developing on embryo-cultured seedlings. A preliminary study of releasing laboratory-bred *N. baraki* on to infested palms did not yield conclusive results. Surveys were initiated to determine natural enemies of the coconut mites and composition of *N. baraki* and *N. paspalivorus* in different agro-ecological regions of infested areas.

The collaborative project with CABI Bioscience, UK funded by the Department for International Development, UK to develop an integrated management program for coconut mite with emphasis on the use of entomopathogenic fungus *Hirsutella thompsonii* was continued. A survey conducted in Puttalam, Anuradhapura, Kurunegala and Gampaha Districts indicated that *H. thmopsonii* was present in all the areas with varying incidence. The highest percentage of nuts with the fungus was obtained from Kurunegala District was 7.6%. Studies revealed that *H. thompsonii* was not infectious to the predatory mite, *N. baraki*. Field studies were initiated to investigate the effectiveness and persistence of four local isolates of the fungus.

Pilot trials continued to determine the frequency of application of a 30% mixture of used engine oil on newly developing nuts to control coconut mite showed that application at monthly intervals gave the lowest damage incidence. The percentage of nuts with no damage at harvest was significantly higher in treated palms than that of untreated palms irrespective of location pick and

frequency of application. A pilot trial to confirm the efficacy of cabosulfan 20% (Marshal SC 20) by root feeding and crown spraying on the reduction mite damage was initiated and pick records were collected. Preliminary field trials conducted to determine the efficacy of soybean oil, fenazaquin and sparrow oil against coconut mite did not give promising results with respect to reduction in population of coconut mite and damage symptoms.

Studies on migration of coconut mite proved that mites disseminate by wind. A survey was conducted in three areas in the Puttalam District to determine the crop loss at harvest due to coconut mite damage. It was found that about 7% of the normal size nuts were free of mite damage. Seventy three percent of the nuts with surface damage were normal in size and shape while the proportion of deformed and empty nuts were very low. A study was initiated to determine the effect of coconut mite damage on immature nut fall at two locations. The study on mite damage and palm nutrition did neither show any relationship between severity of damage and nutrition level of the palms nor a significant difference in the nutrient levels between different levels of nutrition.

A trial was commenced to determine the effect of the fungicides, "contaf" and folicur" in managing leaf rot disease in the field and application of the fungicides by spraying and drenching on to the bud region at monthly intervals was continued.

The study to understand the population fluctuation pattern of the parasitic nematode, *Radopholus similis* infesting coconut roots was continued. Populations of *R. similis* in both the soil and roots were lower than the previous year. A study to identify the difference in the components of the cell sap of healthy and Leaf Scorch Decline affected palms using gas liquid chromatography method was initiated. The study to determine the effect of introducing cell sap of LSD-affected and healthy palms by using test plants, maize and embryo-culture coconut seedlings did not give consistent results.

A total expenditure of Rs.1,365,393.00 was spent from the coconut CESS for research activities to manage coconut mite. A sum of Rs.79,779/- and Rs.910,113/- was incurred as recurrent and capital expenditure for research from the consolidated fund respectively. A total amount of Rs.2,069,879.00 and Rs.1,727,721.00 was spent on research activities of the DFID and CARP projects respectively.

2.5 Plant Physiology

Research project on determining the effect of drip irrigation on micro climatic conditions of the canopy and nut setting of adult coconut palms during dry periods showed that the temperature on the surface of developing nuts, within the canopy and in the manure circle (at 30cm depth) and the leaf stomatal diffusive resistance declines with increasing rate of irrigation (40 L/palm/day, once in 6 days or 80 L/palm/day, once in 3 days) during the present year. A new experiment was started at Bingiriya to determine the growth of root system in coconut seedlings under drip irrigation. The experiments on evaluating the growth and performance of root system of coconut seedlings under different land suitability classes and shade levels were continued. The first destructive sampling was done six months after field planting. Field evaluation of PEG-screened (plants survived in 3-6% PEG solution) embryo-cultured plants for drought tolerance revealed that the stomatal diffusive resistance, rate of transpiration, starch, sugars and proline accumulation in leaves were not different among treatments during the dry period. Hence, it can be concluded that the PEG screening is not a suitable tool to select coconut embryo cultured plants for drought tolerance. A study was commenced to compare the physiological performance of brown dwarf with other two dwarf forms (green dwarf and Cameroon red dwarf) and one tall form (clovis). The critical period of drought during development of the nut on quality of fruit components (kernel, shell, husk, nut water) was identified. A crop growth model for coconut was developed using physiological, soil and weather parameters as inputs and dry matter production in nuts as the output; the UNEP/GEF financially assisted this project.

The protocol for quality preservation of tender king coconuts for a period of one month was obtained by 15 growers/exporters during the year. Vacuum packing of disinfected coconuts (with Benlate 0.6g/L) under cold storage (13-15°C) was identified as a suitable protocol for extending shelf life of up to 38 days for export purposes. The productivity and cost effectiveness of seasonal production of coconut and toddy in the same coconut palm at three monthly intervals (coconut production in lean periods and toddy production in glut periods) was evaluated for increasing the productivity of coconut plantations. It revealed that the seasonal production of two products could be recommended for a higher income from coconut plantations than using the palms for producing coconuts.

Leaf Scorch Decline (LSD) and Tapering Disorder (TD) affected palms were sprayed with complete nutrient solution (macro and micronutrients) at three- monthly intervals and the recovery of the palm is being determined. After one year, there was no improvement in the micronutrient content in the 14th frond with nutrient spraying. However, the chlorophyll content of the leaves was increased and the percentage of affected fronds was decreased in LSD-affected palms with spraying. The pattern of water transport in LSD-affected palms was determined by root feeding of Li. There was an accumulation of Li in the roots of mild and moderate stages of LSD affected palms compared to health palms. Amount of Li transported to canopy was always lower in moderate stage compared to mild and healthy stages. Financial assistance was received from CARP for this study.

2.6 Tissue Culture

During the year, much emphasis was placed on the germplasm exchange program. Embryos of 10 coconut varieties namely, Polynesia Tall, Tagnanan Tall, Vanuatu Tall, Tacunan Green Dwarf, Tahitian Tall, Newlekha Green Dwarf, Tenga Tall, Malayan Red Dwarf, West African Tall and Catigan Green Dwarf were brought from Ivory Coast in September. These embryos were cultured and maintained under *in vitro* conditions. One hundred and four plants raised from embryos (of 4 coconut varieties) brought from India were fully acclimatized and ready for field planting. The germination of embryos brought from PNG was found to be very poor and thus the recovery rate was very low.

A total of 217 Dikiri embryos were cultured during the year and 118 *in vitro* raised plants were successfully acclimatized. Over 30 embryo-cultured Dikiri plants were distributed among growers.

The growth and physiological parameters of the palms (that survived the stress conditions caused by different concentrations of PEG) that had been established at Lenawa Estate were measured.

Five tissue-cultured coconut plants were established at Bandirippuwa Estate to evaluate their performance in the field and 9 more plants are ready for field planting. The growth of the tissue-cultured plants established previously at Bandirippuwa Estate, Lenawa Estate, Daisy Valley Estate and Pallama Seed Garden was found to be satisfactory and three of them came into bearing during the year. No abnormalities in vegetative growth or nut characters were observed in these palms.

Formation of callus in heat-pretreated anthers obtained from inflorescence of 3 WBS (3 weeks before splitting) stage was observed. This was the first time that callus formation in coconut anthers was reported. However, the ploidy level of the callus formed need to be tested to determine whether they are of haploid origin. It was possible to induce callusing in ovule explants excised from female flowers contained within inflorescences of -1 and -2 maturity stages (taking the youngest open flower as 0). However, flowcytometric analysis revealed that the calli are diploid.

The attempts to induce secondary embryogenesis in immature embryo and plumule-derived callus were continued. Callogenesis in plumule and immature inflorescence explants could be enhanced by application of epibrassinolide, a novel plant growth regulator.

Analysis of sugar profiles of inflorescence tissues of different maturity stages was undertaken to generate more information on biochemical markers. The results revealed a higher accumulation of sucrose in -6 to -8 stages that might have some significance in morphogenesis.

Preliminary investigations on cryopreservation of coconut plumules were undertaken and different pre-treatments on encapsulated coconut plumules are being tested to develop effective cryopreservation techniques.

Investigations on embryo culture of "Kitul" *(caryota urens)* were initiated and the preliminary results indicated the possibility of using modified Eeuwens Y3 medium (the medium that is used for embryo culture of coconut for *in vitro* germination and growth of "Kitul" embryos.

2.7 Biometry

The Division continued to assist the research divisions, in designing field experiments and questionnaires for field surveys, sampling methods for socioeconomic surveys, statistical analysis and interpretation of results, use of computers and software packages, and database management.

The computer network system was administrated and the facility was provided to use internet and email to all the divisions. The CRI website (**www.cri.lk**) was developed and updated throughout the year. Also the databases on field experiments, climate, medical aid scheme (MAS) and ledger were updated and maintained.

National Coconut Production

Based on the integrated crop-weather model the predicted national coconut yield for the year 2004 was 2900 million nuts. This was predicted during October 2003. According to Coconut Development Authority the observed yield by December is around 2760 million nuts and therefore the expected percentage error would be around 4.7% The estimated yield for 2005 by the model is 2715 million nuts.

A survey was started during June in order to obtain nut yield from different estates under different districts. Based on data collected up to September the expected yield per palm in 2004 from the districts of Puttlam, Gampaha, Kurunegala and Hambantota would be 68,53,42, and 37 nuts respectively.

In order to obtain more accurate estimates for national oil consumption, a survey was initiated during July with the assistance from District Secretaries. Based on data acquired so far, the following results were obtained (Table 1).

Table 1. *Rate of oil consumption by the householders during 2004 (bottles/person/y)*

District	Month	Numbers of respondents	Mean ± Sd (bottles/person/y)
Gampaha	August	210	7.21 ± 4.48
	July	38	7.53 ± 4.09
Hambantota	September	705	4.59 ± 3.17
Kurunegala	August	210	6.10 ± 3.49
	July	264	5.96 ± 4.06

Analysis of rainfall and temperature in Hambantota (1951-2003) on annual and weekly basis found that there has been significant decreasing trend in the number of effective rainy days (>5mm) and rainfall intensity per effective rainy day. Maximum, minimum, diurnal and mean temperature showed a significant increasing rate. The highest increasing rate was in maximum temperature (0.027^0C per year) followed by mean temperature (0.026^0C/year). The probability of weekly rainfall

exceeds 35 mm is greater than 50% only during 44-46 week (during 28 October to12 November). Based on the past and expected future rainfall and temperature pattern suggest that coconut cultivation would not be a suitable for Hambantota area. Results revealed that farmers should be encouraged for rain water harvest rather than reserve rainy water in tanks.

The number of nuts required for different components were estimated using statistical models based on the past data on nut utilization and coconut production by major coconut growing countries. The estimate was done under two oil consumption rate scenarios: (i) 2 bottles (1 bottle = 0.65 kg) per person per year and (ii) 4 bottles per person per year (Table 2).

Table 2. *Nuts required (in millions) for different stake holders*

Activity	Nuts in million under scenario 1	Nuts in million under scenario 2
Local consumption (fresh nuts)	1937	1937
Desiccated coconut	440	440
Coconut oil for local use	212	424
Copra	86	86
Coconut cream and Coconut milk powder	70	70
Fresh nut export	27	27
Coconut oil for export	24	24
Seed nut requirement	4	4
Total	2798	3032

2.8 Coconut Processing Research

The Division continued thirteen experiments on product development and quality improvement of products using coconut kernel and nut water as raw materials. The total expenditure for maintenance of experiments as recurrent and capital expenditure from the consolidated was Rs. 2,200,000 and Rs.1,905,000 respectively.

Division paid much emphasis on development of coconut kernel based products. Technology developed to produce coconut paste at commercial level was popularized and eight project files were sold to entrepreneurs who requested technology. Out of them one company successfully introduced it to the market. Value addition to the coconut paste was completed successfully introducing instant curry paste for chicken, fish and for white curries. Shelf life of these products is one year at refrigerated conditions. Studies are being continued for further value addition.

A coconut skim milk beverage was introduced using fresh coconut kernel. Different treatments were used in the preparation of coconut skim milk beverage. Sample treated with 1 % CMC, 0.035 % sodium meta-bisulphite and 0.5% flavour was the most acceptable formulation in terms of sensory attributes and chemical composition.

The ready-to-drink beverage (concentrate diluted at 1:3 ratio) made from this formulation contained 1.0% protein, 0.84% fat, 18.70% sugar and 79.25% water. The beverage concentrate was found to be stable for 4 months at storage under ambient temperature (30^0) as revealed by minimal changes in chemical composition and had very low microbial activity. The shelf –life studies are being continued.

Proximate composition and pectin properties of Dikiri coconut kernel were analyzed with the objective of utilizing Dikiri coconut for value addition. Results revealed that the Dikiri coconut contains "high methoxyl rapid set' pectin and Dikiri coconut contains relatively low content of fat compared with normal coconut. A coconut jam was developed with nuts of 9-10 months maturity and

the shelf life of the product is one year. Studies further revealed that the product is comparable with other commercial fruit jam. The studies conducted with defatted coconut powder revealed that it could be easily be converted to instant sambol. Shelf life of the instant coconut sambol is being carried out.

The effect of different extraction methods on proximate composition and fatty acid profile of coconut milk was studied. The composition of coconut milk vary depending on the amount of water used and method of extraction of coconut milk. The highest fat extraction was observed by blending followed by hand squeezing. Grinding followed by hand squeezing extract more proteins and short chain fatty acids. Hand squeezing using cold water produced higher amount of lauric acid.

Four trials on DC manufacture was conducted at Dunagaha DC mills to evaluate qualitatively and quantitatively, the suitability of T x T (CRIC 60) and DG x T (CRIC 65) for DC manufacture. Preliminary results revealed that DG x T (CRIC 65) has a little low DC out -turn compared to T x T.

Dry processing method was successfully introduced to extract virgin coconut oil. Analytical parameters of virgin coconut oil are within the SLS specification standards. Shelf life studies of virgin coconut oil and value added products are being continued. Medium chain fatty acids have very high demand because of their nutritional value. Fractional cristalization of coconut oil was attempted, in order to obtain medium chain fatty acid enriched fraction.

2.9 Technology Transfer

Several programs were implemented by the Division to transfer new technologies to coconut growers and the Extension Staff of the Coconut Cultivation Board. During the year priorities were given to educate and update the technical knowledge of Extension and Field Staff of CCB particularly on interim recommendations as measures to manage coconut mite infestation. Several seminars and field demonstrations were conducted for the CCB officials for the above purpose. In order to enhance the direct linkages with stakeholders, a series of seminars, field days, trainings and educations programs were conducted for coconut growers, members of Kapruka Samithi, relevant officials of the government, and non-governmental organizations.

During the year the Division produced a series of video documentaries on recommended practices of the Institute. The production of six video documentaries of 20 minutes were completed during the year on coconut mite control, irrigation of coconut, Red Weevil control, Intercropping under coconut, Coconut Caterpillar control and animal husbandry in coconut lands. Copies of these documentaries are available in VCDs for coconut growers at a subsidized price of Rs.100/- each. As these copies are in high demand, they are made available for sale at CRI and CCB Head Office in Colombo. To mark the anniversary of the Institute, a video documentary was produced in both Sinhala and English languages covering the activities and services offered by the Institute. These two documentaries were telecast over Rupavahini in two different days with ten 30 second video spots prepared separately on ten technical areas. A weekly radio program named "Kapruka Pamula" was broad cast over the Commercial Service of SLBC in collaboration with CCB and CDA. The Institute received very high response for these media programs from the general public and stakeholders. Media arrangements were made for the Institute staff to participate in live radio and TV programs. Several articles and news events were published in newspapers.

During the year under review, a significant increase in the number of coconut growers who visit the Institute seeking technical advice for their field problems was observed. The number of students, entrepreneurs and officials of other Institutions seeking technical services is also increased during the year. Over seventy five educational programs were conducted for nearly 6500 students who visited the Institution from different areas of the country. The number of advisory correspondence and telephone communications has also shown a significant increase. Nearly 30 medium and large estates were inspected by the Staff of the Division to provide technical advice and guidance on the development and rehabilitation of coconut lands.

A number of studies were conducted by the Staff of the Division on the assessment of knowledge level and factors affecting the adoption of Red Weevil control measures of the coconut small holder sector in the Kuliyapitiya Region, the assessment of the constraints of coconut small holders and the level of coconut mite infestation in coconut growing areas. The Division organized five exhibition stalls for the benefit of the general public during the year.

Publication of an attractive series of revised advisory circulars was commenced. A new publication titled as Technology Update which was prepared with the objective of quick transfer of technology was commended by stake holders. The publication is printed in an attractive colour format once in very four months and distributed to coconut growers and Extension Officers of CCB. In addition to the above publications the Division published COCOS, Advisory Bulletins, Advisory Circulars, Annual Reports, New Booklet on Gliricidia Cultivation and management, Corporate Plan of the CRI and Conference publications.

2.10 Library

Routine services of the Library were conducted satisfactorily throughout the year. Bibliography on staff publications was compiled to mark the 75th Anniversary of the CRI. Special attempt was made to strengthen the reference collection with electronic resources. Accordingly, decided to subscribe 8 e-journals.

The smooth functioning of the Library was disturbed during the year due to the delay in recruiting necessary Staff.

2.11 Estate Management

The major functions of the Division: a) To facilitate research activities by providing labour, land and materials, b) seed nuts and coconut production, c) provide other plant/animal materials, d) activity for dissemination of technology transfer were successfully continued during the year.

From the three Seed gardens at Ambakelle, Maduru Oya, and Pallama, 1,322,757 seed nuts were issued for the National Coconut Planting Program and majority to nurseries managed by the Coconut Cultivation Board and revenue of seed nut production was Rs.17.06 million. In general, 41% increase in seed nut production was noticed over the same period of the previous year. During the period green nut production was 5.9 million nuts and majority of these were sold through the CDA Auctions.

Total value of nut production was Rs.52.57 million. The other sundry income was Rs. 3.27 million giving the cumulative income of Seed Gardens and Estates as Rs.72.90 million.

The average Cost Of Production (COP) for a nut was Rs.6.5 while Net Sale Average (NSA) was Rs.9.65. The lowest COP was recorded this year too at Makandura, as Rs.4.26 per nut and this was supported by high production and uniformity of the coconut plantation.

Rainfall varied from 2145 mm (102 wet days) in the Wet Zone, 1184 mm (78 wet days) in the Intermediate Dry Zones and to 1831.3 mm (90 wet days) in the dry zone.

Manure was not applied during the year 2004 at Makandura Estate. The second crop was not collected at Makandura as the Estate was taken over between 14/01/2004 to 29/04/2004 by the Board of Investment.

The physical progress of the third Seed garden at Pallama was satisfactory and 8735 seedlings/young palms were well maintained for future seed nut production of SR x T variety by the Genetics & Plant Breeding Division.

As usual, cultural practices such as husk burying, weeding, contour drains were followed according to the schedule.

Mite damage at the Maduru Oya Seed garden was considerable and all affected palms were treated separately with neem oil mixture and by applying burned oil mixture. The reduction of mite damage was observed with the continuation of these treatments.

2.12 Establishment Unit

No recruitments were made as directed in Administration Circular No. 14, 15 and 16 dated 03 January, 23 August and 01 October 2002 respectively.

As at 31 October 2004, the Staff strength of the CRI was 324 and almost 362 daily paid labour gang was working in 5 Research sub-stations and 04 Seed gardens. In order to achieve the targets committees had been set up consisting of Heads of Divisions.

Total budgetary allocation for this year was Rs.105.650M and out of which Rs.82.650M under recurrent and Rs.23M under capital expenditure. The total estimated revenue for the year was Rs.12.150M. Therefore, the Government grant was Rs.83.270M. The details of expenditure including salaries and major expenses are given below:

			Rupees Mln.
a)	For Staff salaries, labour wages, overtime and Board contributions for Medical aid, Provident Fund, ETF	-	77.473
b)	Gratuity for 38 members who left the services of the Institute	-	3.859
c)	For welfare activities	-	0.500
d)	For the local training granted for 18 officers	-	0.148
e)	For the overseas seminars, workshops, trainings granted for officers (excluding foreign grants)	-	0.160

2.13 Services provided by Research Divisions

a. Genetics and Plant Breeding Division

The Division continued to assist fresh coconut exporters by inspecting nuts and issuing certificates to guarantee the quality of nuts.The Division launched private sector nursery registration program after inspection of lands and other physical resources.

b. Soils and Plant Nutrition Division

The Division offered following services to the stakeholders:

Differential Fertilizer Recommendation	-	95 growers (4200 ac)
Land suitability tests for coconut cultivation/surveys	-	23 growers
Inorganic fertilizer analysis	-	128 samples
Organic fertilizer analysis	-	54 samples
Analysis of coir pith samples	-	503 samples
Soil analysis	-	1223 samples
Leaf analysis	-	2405 samples
Water analysis	-	16 samples
Participation in training programs	-	01

c. Crop Protection Division

The Division continued to serve the coconut growers during the year. Advice on management of pests and diseases were given, while field inspections were made in instances where specialized advice was required. Many infestations of coconut caterpillar were reported from several areas and they were successfully managed by releasing nearly 865,6000 laboratory-bred parasitoids. A total of 3093 pheromone vials were sold and 32.11 of monochrotophos was issued to the growers to manage red weevil.

d. Coconut Processing Research Division

The Division sold a few technologies to entrepreneurs to commence coconut based product processing.

They conducted demonstrations on coconut product processing to various community groups, farmer organizations etc. to transfer technology.

3. DONOR FUNDED PROJECTS AND COCONUT CESS FUND ASSISTED PROJECTS

3.1 Donor funded projects

1) Project Title: Evaluation of the physical performance and functional structure of the coconut marketing system in Sri Lanka - CARP contract Research Program (12/496/369)

The objective of this study is to evaluate the structure and the performance of the existing coconut marketing system for fresh coconut, desiccated coconut and copra industries, focusing on Kurunegala, Puttalam and Gampaha Districts in Sri Lanka. A baseline survey was done to collect relevant information coupled with regular price monitoring process throughout a 12 months period. Major findings of the study revealed that a majority of the smallholders sells their nuts through middlemen creating lengthy channels, while a majority of estate owners practices direct selling to desiccated coconut/copra mills or direct disposing to brokers. The number of middlemen consist in the channel varies from 1-10, until the nut reach it's destination. There are several categories of middle dealers in a typical coconut-marketing channel, i.e. Primary Collectors, Middle level collectors, Brokers, Wholesalers, Retailers and Exporters. The middle dealers decide their buying and selling prices for fresh coconuts mainly depending on the desiccated coconut and copra prices.

Hence, the farm gate price of coconuts is significantly determined by the desiccated coconut and copra prices. Overall, all the intermediaries in the channel extract more than Rs.0.5 per nut at each level. Thus, the coconut producer only gets 67% of the consumer price for a coconut he sells into the system. The provisional coconut auctions can be considered as corrective measures to lessen the number of intermediaries involved in the marketing system and to shorten the marketing channels especially benefiting the large number of coconut smallholders.

(Total expenditure of the project: Rs.259,629.03 for 15 months)

Note: The study was completed in December 2004

CARP funded project

2) Project: Earthworm mediated composting system in coconut lands

This project showed promising results and the potential of using this technique in coconut lands. This is an alternative approach to develop low cost sustainable soil fertility management system to cater the issues of increasing cost of fertilizing and continues degradation of coconut soils.

Perionyx sp., and *Eudrilus sp.* could be used for vermicomposting in the coconut triangle as they were found to be better adapted for the warm climatic condition. Composting process was completed with in 4-5 weeks with the above species. Vermicompost showed positive effects of growth of coconut seedlings in comparison to compost. It was also shown to induce the root growth of the plants. Vermiwash has growth stimulating effect when it was used in combination with vermicompost. Addition of vermicompost to the potting media has shown to increase nitrate –nitrogen content in comparison to composts, which may enhance the uptake of nitrogen.

This technology is going to be introduced to the CRI estates initially.

Foreign Funded project

3) Project: Poverty reduction through coconut based interventions in poor rural communities in Sri Lanka

This is primarily research & development project with the objective to develop sustainable coconut –based income generating technologies for poor rural communities through production & marketing of high value coconut products, intercropping and livestock, increase the access to high quality planting material while conserving the genetic diversity of coconut in the rural community and ultimately project hypotheses that poverty in rural areas can be reduced through coconut based interventions.

Marketable products, that can generate the income for these communities were identified from Market surveys in the respective communities. Thereafter trainings were arranged accordingly. During the project period 1006 men and women were trained of whom more than 75% are women. The three communities selected are engaged in the production of coconut based high value products such as coco shell handicrafts, fiber (yarns, doormat, Brushes), ekel (Brooms), kernel (virgin oil, white copra, sweets, crude oil, soap), coconut water (venigar), sap (Treacle), bracts handicrafts under the patronage of the "Poverty Reduction Project".

In addition, the introduction of coconut based livestock systems (Poultry, quills, Goat, Cattle) & intercropping have generated the income. Production of value added milk products has shown promising progress in the communities.

The results of the baseline survey revealed that some notable changes have occurred among the beneficiaries, who has benefited by the project activities. The project could successfully introduce alternative income generation activities for the rural poor in these communities, which were not explored or supported before. In addition, the project has also positively intervened to enhance nutrition level of the rural poor communities.

The project was completed in November 2004.

4) **Project: Assessment of the Impacts of and Adaptations to Climate Change in the Plantation Sector, with particular reference to Coconut and Tea, in Sri Lanka (START funding)**

By incorporating soil suitability class for coconut (SSC) five different **crop climate models** were developed to assess the impact of climate change on coconut productivity on spatial and temporal scales within the five agro-ecological regions of coconut growing areas. In collaboration with Indian Agricultural Research Institute, New Delhi, a basic **crop model** for coconut was developed using crop physiological data, weather data and soil data as inputs and dry matter of coconut yield as output. The latter model was linked with the SRILANKACLIM model. In the **Ricardian survey**, of the total sample of 144 farmers, 60 farmers have already been interviewed and data of 50 farmers have been computerized for analysis.

5) **Project: Identification of some possible causes of Leaf Scorch Decline (LSD), Tapering (TD) and Rapid Decline (CRD) disorders of coconut palm (CARP, 12 / 537/ 408)**

To investigate the effect of nutrient spraying on the reduction of LSD symptoms and new root formation, total nutrient solution was sprayed to the canopy of affected palms at Bandiruppuwa, Poththukulam and Walpita Research Stations at three monthly intervals. The number of scorched fronds in the canopy was reduced with time with nutrient spraying treatment. However, the improvement in leaf chlorophyll and nutrient contents were not yet consistent. To investigate cellular abnormalities and pathogen associations with LSD, CRD and TD, root, trunk, leaf and flower vasculate tissues of affected and healthy coconut palms were sent to Iowa State University, USA for transmission electron microscopy (TEM) analysis. To determine the pattern of water transport and diagnose any blockages in the LSD, CRD and TD affected palms, treated water was trunk injected to affected palms and the presence of ^{3}H in transpired water of leaves, water of developing nuts, trunk and roots is being analyzed.

6) **Project: Molecular marker-based characterization of conserved coconut germplasm in national genebank and selected farmers' varieties in the IPGRI/COGENT poverty reduction project sites in Sri Lanka" (Funded by IPGRI/COGENT)**

A microsatellite kit comprised of 14 SSR primers, developed by CIRAD/France for COGENT/IPGRI was used to generate molecular data from five accessions of Sri Lanka tall coconut accessions namely Ambakelle tall, Moorock tall, Colvis tall, St. Anne's tall and Debarayaya tall and from seven farmers varieties, three varieties each from two sites, Wilpotha and Hetipola and one from site Dodanduwa, namely Kumbuke pol, Kadawala pol and Muhuriya pol from site Wilpotha and Nuwara Kelle pol, Tharana pol and Wariya pol from site Hettipola and Dadalla pol from site Dodanduwa. Each Sri Lankan tall variety was represented by 20 palms while each farmer's variety was represented by 15 palms. In addition, seven Sri Lanka dwarf green variety were also included into this DNA assay as a control variety. DNA isolation was completed from tender leaves of all varieties. Isolated DNA was subjected to microsatellite analysis and data were collected for eleven pairs of microsatellite primers.

During the project work, two graduates from the university of Colombo Sri Lanka were trained on the use of PCR techniques, microsatellites assay, gel electrophoresis techniques and silver staining procedure.

7) **Project: Identification of coconut varieties by DNA markers (Funded by International Foundation for Science, Sweden)**

Two microsatellite primers that can distinguish coconut varieties, tall x tall, dwarf green, dwarf yellow, dwarf green x tall and dwarf yellow x tall were identified. Twenty yellow colour seedlings appeared in a dwarf yellow x tall hybrid bed in the nursery that were normally discarded as illegitimates, were checked for their identity and was found that some of the yellow seedlings discarded were hybrids. The research project is continuing.

3.2 Cess Fund Assisted projects

1) Project: Importation of coconut germplasm

During the year two hundred embryos each from 10 varieties of coconuts, namely Tagnanan tall, Tahitian tall, Tenga tall, West African tall, Tacunan
green dwarf, Catigan Green dwarf, New lekha green dwarf were collected from CNRA, Ivory Coast and brought to the country. A batch of 145 plants raised from Indian varieties are now ready for field planting. Some embryos of varieties brought from Papua New Guinea found to be very poor in germination.

2) Project: Application of biotechnology for molecular pathogen diagnosis

Necessary enzyme assay kits were purchased for molecular marker studies. Experiments were continued for screening of phytoplasma. So far no molecular evidence to believe that "rapid decline" syndrome is caused by viroid or phytoplasma.

3) Project: Strengthening analytical facilities for DFR

Incubator was purchased. Analysis of leaf and soils samples for differential fertilizer recommendations is being continued. Hundred and ten Leaf samples collected from different estates were analyzed to provide differential fertilizer recommendations at the request of the growers.

4) Project: Mite research and extension program to control coconut mite

In January a workshop was held at the CRI inviting entomologists in the country and appointing a panel to review the research activities carried by the CRI and to make necessary recommendation. External review panel commended the activities so far carried out and recommended a long-term research program on nutritional status of coconut palms and intensity of mite infestation, screening of varieties for mite tolerance and population dynamics of coconut mite with time and threshold value for economic damage.

Early part of the year mite infestation was reported in Hambanthota District and control measures were implemented immediately to prevent further spread of infestation. To educate about mite infestation, identification of affected palms, and control measure, several mass media programs were carried out using electronic media. Towards the latter part of the year action was initiated to implement island wide mite control program.

5) Project: Increasing production of CRI 65 seed nuts

Action has been taken to establish 100 acre dwarf mix tall block at Genetic Resource Centre at Ambakelle. Preliminary action was taken to establish drip irrigation system for this 100 acre block at ISG. Proposed irrigation system could not establish due to the shortage of funds, hence it was postponed to next year.

6) Project: Technology transfer program

Three documentaries on Red Weevil control, Irrigation of coconut, coconut mite control methods were produced and telecast in national TV. 1000 CDs were prepared using these documentaries and distributed for the benefit of growers at a very minimal cost. A new series of advisory leaflets was printed with colour coding. A weekly radio program was conducted in collaboration with CDA and CCB to transfer technology and educate the growers.

7) Project: Red weevil control

Procurement of required chemicals was completed. Synthesis of pheromone was carried out successfully and distribution of pheromone was carried out through regional extension officers.

4. ACKNOWLEDGMENTS

The co-operation extended by the Deputy Director (Research), Deputy Director (Administration and Finance), Heads of Divisions, and Staff of the Research and Service Divisions contributed to the successful implementation of the Annual Action Plan. Their contribution is gratefully acknowledged.

CRI is also thankful to Hon. Minister, Deputy Minister, Secretary, two Additional Secretaries and other Staff of Ministry of Plantation Industries for their excellent cooperation provided to CRI for successful implementation of the year 2004 action plan.

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 CESS Committee
- 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
- National Institute of Plantation Management
- ADB funded Science and Technology Personnel Development Project
- Second Perennial Crop Development Project
- Water Resources Board
- Department of Botany, University of Peradeniya
- Postgraduate Institute of Agriculture (PGIA)
- Postgraduate Institute of Science (PGIS)
- Industrial Technology Institute (ITI)
- National Science and Technology Commission (NASTEC)
- Kurunegala Plantations Ltd.
- Central Plantation Corp Research Institute, India
- Indian Council for Agricultural Research
- Coconut Genetic Resource Network
- Asia and Pacific Coconut Community, Indonesia
- International Service for National Agricultural Research (ISNAR)
- International Mycological Institute, UK
- Food and Agricultural Organization (FAO)

REPORT OF THE AGRONOMY DIVISION
Acting Head - M T Neil Fernando, PhD

1. General

Research programme focussing on development of innovative agronomic practices for: a) increasing coconut production and b) increasing land productivity by intercropping, animal husbandry, fuel wood farming, and studies on economic issues were continued. During the year, 23 field experiments and 6 socio-economics studies under 10 major research projects were conducted. Total allocation of consolidated funds in terms of capital and recurrent budget for the above studies was Rs 2.322 million and Rs 4.851 million respectively.

Five major outside projects funded from external sources were in operation. The ADB-funded; Coconut-based Adaptive Research Project (Rs 2.0 million), Poverty Reduction in Coconut Growing Communities (Rs 1.3 million), CESS-funded Fuel Wood Plantation Project (Rs 0.2 million), CARP-funded Improvement of Productivity of Coconut Soils through Vermiculture Technology (Rs 0.168 million) and CARP-funded Physical Performance and Functional Efficiency of the Coconut Marketing System in Sri Lanka (Rs 0.36 million).

Harrowing of sandy regosols soils in Palavi as a measure of pruning of heavy root mat has not shown a significant effect on coconut yield.

Application of Diuron at the rate of 3.2 kg ai/ha was found to be effective to control weeds in coconut nurseries and this practice saves Rs. 1287 for 1000 coconut seedlings as compared with manual weed control. Moreover, 4.0 l of Glyphosate per hectare was economically effective in controlling weeds in mature coconut plantations as compared with slashing and cover cropping.

Planting of T x T coconut seedlings in 1.3 m wide x 1.3 m deep trench (filled with husks/same soil) in Andigama soils has significantly increased the number of leaves produced and has influenced the early flowering (41%), as compared with the seedlings planted in standard pits (1m x 1m x 1m).

Results of the rehabilitation trial at the Andigama soil series revealed that *Acacia mangium* and *Macaranga paltata (Kendas)* trees could be effectively used as short rotation forest trees owing to their fast growth. Multi-locational trial on husk burial showed that large sized husk pits (2.5 x 1.3 x 1 m) placed between coconut avenue could increase the nut yield over control palms.

Experiment on the management of leguminous ground covers to improve the productivity of coconut lands revealed that application of fertilizer plus harrowing could significantly increase the nut yield irrespective of the soil type.

Performance of bud-grafted and air layered cashew was higher in terms of seed weight and number of seeds in compared with seedling cashew, though the value were not significant different. Intercropping of cashew did not influence the coconut yield indicating the ability of growing cashew as a potential intercrop under coconut.

Export performance of mattress fibre and bristle fibre is significantly and positively influenced by the world market prices of final products produced using them, namely mattress bedding and coir brushes, and by the one-year lag national coconut production. These imply that the market promotion of coir products and measures to increase the national coconut production are imperative to improve the export performance of mattress and bristle fibre. Export price elasticities of demand of mattress and bristle fibres found to be inelastic, relatively small and not significant. These imply that the export demand of mattress and bristle fibres is less responsive to export own price changes. However, Sri Lanka should not attempt to export coir in the form of raw fibre, but should strive to export them in the form of finished products.

A strategic approach to increase the national coconut production which includes: a) minimization of fragmentation of high potential coconut lands, b) expansion of coconuts into non-traditional areas, c) optimization of coconut production in lands which provide less than optimal yields, and d) a rigorous home garden cultivation program is suggested.

The economic value of climate variability on coconut production was found to be vary from Rs.197 million to Rs. 6601 million per annum. This implies that the incremental public expenditure on climate adaptation strategies on coconuts such as supplementary irrigation, moisture conservation etc, even to the tune of Rs. 6601 million per annum would be remunerative and hence justifiable.

The land area under coconuts was 416235 ha in 1982 and 394836 ha in 2002, representing 21417 ha (5%) reduction during 20 years, which is equivalent to an annual rate of 1071 ha loss of coconut lands. The biggest net looser of coconut lands is the Kurunegala district followed by Gampaha and Puttalam districts, while the biggest net gaining district is Anuradhapura.

2. RESEARCH PROJECTS

PROJECT 2: REHABILITATION OF LOW YIELDING PLANTATIONS

Experiment 2.3: 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 experiment has been laid on a Randomized Complete Block Design (RCBD) with three replicates containing nine effective palms per plot. The soil is 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 2004, root pruning by disk harrowing (15 cm depth) and application of 3.0 kg of APM + 1.0 kg of dolomite/palm were continued according to treatments given in Table 1.

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

	Nuts/palm/year		
Treatments	2002	2003	2004
Control (no fertilizer + no harrowing)	27	46	55
Harrowing + Fertilizer	63	56	58
Harrowing only	42	40	49
Fertilizer only	47	49	58
Significance	**	n.s.	n.s.
LSD (P=0.05)	12		

In year 2004 too the nut yield did not differ significantly among treatments as in year 2003 (Table 1). However, the nut yields have increased in all treatments compared to year 2003.

The experiment is being continued.

H A J Gunathilake, S D J N Subasinghe & E M G Banda

Experiment 2.4.2: Effect of size of planting hole on the growth of T x T seedlings on the Andigama Soil Series (shallow phase): Rathmalagara Estate (IL_1/S_5) Madampe - 1997

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

In year 2004, there were no significant differences in total number of fronds among treatments. Although not significant, seedlings planted in standard size pits had the lowest number of leaves compared to other treatments. It was also evident from the number of leaves produced, which was significantly lower than the other treatments.

Table 2 shows the extent of reproductive attainment as a percentage of palms flowered in year 2004. Seedlings planted in standard size pits showed the lowest flowering percentage while the highest was recorded in trench planting.

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

Treatments	Total Number of fronds/palm	Number of leaves produced	% Flowering
T_1 1 x 1 x 1 m pit (standard planting hole)	10	7	5
T_2 1.3 x 1.3 x 1.3 m pit (filled with husk/same soil)	13	8	17
T_3 1.3 x 1.3 x 1.3 m pit (filled with husk/soils brought from out side)	14	8	33
T_4 1.3 m wide x 1.3 m deep trench (filled with husk/same soil)	12	8	41
T_5 T_4 + 20% increased standard density of palms (156/ha)	12	8	58
Significance	n.s.	*	
LSD (P=0.05)		0.9	

The experiment is being continued.

H A J Gunathilake, H A Abeysoma, I M Thilakaratne & W A Hemawardena

Experiment 2.4.5: 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 economical coconut production. The forest tree species used in this experiment have been planted in a Randomized Complete Block Design (RCBD) with three replicates (Table 3).

Among the tree species under study, two provenances of *Acacia mangium* and *Macaranga palata* (Kendas) showed a high growth rate as measured by stem girth at 30 cm and 130 cm above ground (Table 3). The growth rates of *Calophyllum eletum* (Domba) and *Swieterwia macrophylla* (Mahogani) remained significantly low as in the previous years. Due to the higher vegetative growth of Kenda and Acacia, plots with these trees showed a very low weed count in contrast to the plots with slow growing trees. However, the lowest weed count was recorded in Gliricidia plots despite the relatively low growth rates observed. This may be due to the low light penetration through the canopy and higher competitiveness of Gliricidia over weed species for soil nutrients and moisture.

Table 3: *Growth of selected forest tree species*

Treatments	Stem girth (cm) (at 30 cm above ground)		Stem girth (cm) (at 130 cm above ground)	Number of weed species per m^2
	2003	2004	2004	2004
T_1 *A. auriculiformis*	39	45	40	73
T_2 *A. mangium-1*	41	50	44	32
T_3 *A. mangium-2*	44	57	44	20
T_4 *Calophyllum elatum*	14	18	14	161
T_5 *Grewia tilifolia*	22	22	20	103
T_6 *Macaranga paltata*	46	52	44	17
T_7 *Gliricidia sepium*	23	26	23	10
T_8 *Tectonia grandis*	27	32	27	58
T_9 *Swieteria macrophylla*	21	26	21	96
T_{10} *Bridella mooni*	33	37	30	27
Significant	***	**	***	***
LSD (P=0.05)	2	7	4	5
CV%	13	17	11	16

The experiment is being continued.

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PROJECT 3: DEVELOPMENT OF AN IMPROVED PACKAGE OF MOISTURE CONSERVATION PRACTICES FOR SOIL CLASSES 3, 4 AND 5 TO INCREASE YIELD OF COCONUT

Experiment 3.3: Study the effect of husk burial and mulching on coconut yield

The experiment was conducted at the following sites.

3.3.1 Minuwangoda (WL_3/S_4) - 1996
3.3.2 Hettipola (IL_1/S_3) - 1996
3.3.3 Pallama (IL_1/S_2) - 1996

Effect of various methods of burying husks in pits and mulching (Table 4) are being tested on a RCBD with three replicates with nine effective palms per plot in four sites, representing two different agro-climatic zones and three soil suitability classes. In year 2004 also, there was no consistency in treatment effect on nut yield in the three sites as in the previous year.

At Minuwangoda site, overall increase of nut yield due to application of different moisture conservation methods was 41% over control (no application). The highest nut improvidence (48 nuts/palm/yr) was in coconut palms with 2.6 x 1.3 x 1.0 m sized husk pits (T_8) in between two palms over control (T_1) (29 nuts/palm/yr) and next was palms with husk mulch (T5). However, mulching with fronds did not increase the nut yield as observed in mulching with husk

As in the previous year, there were no significant differences in nut yield among treatments at Hettipola site in 2004.

Table 4: *Coconut yields (nuts/palm/year) as affected by different methods of husk burial and mulching*

Treatments	Minuwangoda		Hettipola		Pallama	
	2003	2004	2003	2004	2003	2004
T_1 - Control (Standard practices)	29	33	41	30	52	44
T_2 - Mulching with 12 fronds	32	41	49	28	53	40
T_3 - T_1 + 1/3 circle trench filled with same soils	33	45	35	29	40	43
T_4 - T_1 + 1/3 circle trench filled with husk	43	49	49	25	39	42
T_5 - Mulching with husk	47	47	39	25	46	41
T_6 -T_4 + T_5	46	49	36	26	41	42
T_7 - 1.3 x 1.0 m trenches	38	43	33	24	38	38
T_8 - 2.6 x 1.3 x 1.0 m husk pits between two palms	48	45	39	29	42	42
T_9 - 1.3 x 1.3 x 1.0 m husk pits for every palm	50	46	42	27	40	36
Significance	*	*	n.s.	n.s.	*	*
LSD (P=0.05)	15	15			14	8

The experiments are being continued.

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PROJECT 5: IMPROVEMENT OF ORGANIC MATTER STATUS AND WATER HOLDING CAPACITY OF COCONUT SOILS

Experiment 5.1: Management of leguminous ground covers to improve productivity of coconut

Experiment 5.1.1: Pallama Seed Garden, Pallama - DL1 - (Katukele Series) - 2000

5.1.2: Melsiripura Farm, Melsiripura - IL1 - (Melsiripura Series)-2000

The objectives of the experiment are to evaluate and quantify the effect of leguminous ground covers and their management methods on the productivity of coconut plantations in the long run. Treatments shown in (Table 5) were laid on a two Factor Factorial Randomized Complete Block design with three replicates and nine effective palms per plot.

Different treatments were applied according to the schedule. Plots were treated with two types of fertilizer mixtures with N and without N (N, P, K, Mg and P, K, Mg) for coconut palms and two types of ground cover management methods, harrowing and slashing, twice a year.

Table 5. *Effect of ground cover management on coconut yield (nuts/palm/year) at Pallama Seed Garden and Melsiripura estate*

Treatment combination	Melsiripura				Pallama			
	2001	2002	2003	2004	2001	2002	2003	2004
T_1 - Pueraria cover + P,K,Mg + Slashing	56	82	85	73	73	26	73	91
T_2 - Pueraria cover + N,P,K,Mg + Slashing	59	66	90	68	78	39	75	92
T_3 - Pueraria cover + P,K,Mg + Harrowing	55	68	73	70	74	33	67	90
T_4 - Pueraria cover + N,P,K,Mg + Harrowing	50	66	69	92	71	27	63	101
Significance	ns	ns	*	*	ns	ns	ns	*
LSD (P=0.05)			16	13				8

During the year, there was a significant difference in yield among the treatments (fertilizer mixtures and cover management methods) in both experiments.

The experiment is being continued.

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PROJECT 15: DEVELOPMENT OF LOW COST WEED MANAGEMENT SYSTEMS FOR COCONUT LANDS AND COCONUT NURSERIES

Experiment 15.1: Comparison of several recommended cultural practices for weed management in coconut lands

15.1.1: Pallama Seed Garden (IL_1/S_4)

15.1.2: Ussawa Division, Melsiripura Estate (IL_1/S_3)

Treatments shown in Table 6 were laid on RCBD with three replicates and there are nine effective palms per plot. Different weed management treatments were applied according to the schedule. During the year, more frequent sampling was practiced to understand the dynamics of weed biomass in response to different cultural practices for weed management. Soil samples were taken to measure soil moisture content at two depths (0.5 ft and 1.0 ft). The major weed species present in these sites were Illuk (*Imperata cylindrica*), Mana (*Panicum repens*), Getakola (*Hedyotis auricularia*), Podisinghomaran (*Chromolaena odorata*), Gandapana (*Lantana camara*) and Nidikumba (*Mimosa pudica*).

T_1 - Control treatment (in which only the perennial shrubs were managed)
T_2 - Cover cropping with Pueraria
T_3 - Planting Gliricidia (in double rows in an avenue at 1m x 2m spacing)
T_4 - Slashing (two times per year)
T_5 - Application of Glyphosate (4lit/ha, two applications per year)
T_6 - Grazing with cattle (6 rotations per year)

There was a significant difference among treatments on weed biomass. The lowest weed biomass was in Glyphosate applied plots while the development of Pueraria cover was also equally effective to suppress weeds as in Glyphosate applied plots in Pallama and Melsiripura (Table 6 and 7). Nut yield of coconut as affected by the application of different cultural practices show significant differences during the year in Pallama and Melsiripura experiments (Table 8), highest nut yield was given by chemical weed control plots. Soil moisture content was significantly higher in Glyphosate applied plots at 1.0 feet level in both experiments (Table 9).

Table 6: *Weed biomass (g/m^2) at different sampling times as affected by the application of different weed control practices at Pallama Seed Garden, Pallama*

Treatments	Ave 01	Ave 02	Ave 03	Feb 04	April 04	June 04	Aug 04	Oct 04	De 04
T_1- Unweeded	238	168	179	164	135	46	148	129	179
T_2- Cover crop (Pueraria)	193	135	16	0	0	0	0	0	0
T_3- Gliricidia	216	129	150	121	84	31	102	102	90
T_4- Slashing & mulching	168	126	146	85	121	54	137	116	122
T_5- Chemical weeding	150	39	28	0	17	24	67	65	85
T_6- Cattle grazing	227	147	189	152	137	49	220	125	132
Significance				**	**	**	**	**	**
LSD (P=0.05)				40	57	10	55	54	68

Treatments were applied in June 01, December 01, June 02, December 02, June 03, December 03, June 04 and December 04.

Table 7: *Weed biomass (g/m^2) at different sampling times as affected by the application of different weed control practices at Melsiripura estate, Melsiripura*

Treatments	Aver 2002	Aver 2003	Feb 04	April 04	June 04	Aug 04	Oct 04	Dec 04
T_1- Unweeded	168	177	218	147	186	114	146	268
T_2- Cover crop (Pueraria)	135	16	2	0	14	0	14	48
T_3- Gliricidia	129	150	142	98	136	105	80	122
T_4- Slashing & mulching	126	146	143	118	280	88	114	201
T_5- Chemical weeding	32	28	15	68	127	24	82	96
T_6- Cattle grazing	147	189	148	126	246	114	137	185
Significance			**	**	***	**	**	**
LSD (P=0.05)			91	70	95	85	75	65

Treatments were applied in June 01, December 01, June 02, December 02, June 03, December 03, June 04 and December 04.

Table 8: *Nut yield of coconut as affected by different cultural practices in controlling weeds at Pallama Seed Garden and Melsiripura estate*

Treatments	Nuts/Palm/Year							
	Pallama				Melsiripura			
	2001	2002	2003	2004	2001	2002	2003	2004
T_1- Unweeded	72	26	68	82	46	56	59	48
T_2- Cover crop (Pueraria)	88	38	87	101	45	52	61	51
T_3- Gliricidia	77	38	74	84	59	49	56	53
T_4- Slashing & mulching	78	27	81	87	54	50	51	50
T_5- Chemical weeding	81	44	97	102	44	61	78	69
T_6- Cattle grazing	83	36	75	81	58	46	53	47
Significance	ns	ns	*	*	ns	ns	ns	*
LSD (P=0.05)	-	-	15	13	-	-	-	12

Table 9: *Soil moisture content (%) as affected by different cultural practices in controlling weeds at Pallama Seed Garden and Melsiripura estate*

Treatment	Soil Moisture Content (%)			
	Pallama		Melsiripura	
	0.5 ft (depth)	1.0 ft (depth)	0.5 ft (depth)	1.0 ft (depth)
T_1 - Unweeded	2.43	3.29	3.72	4.55
T_2 - Cover crop (Pueraria)	3.72	3.32	4.78	5.63
T_3 - Gliricidia	2.48	3.81	2.72	5.95
T_4 - Slashing and mulching	2.25	3.37	3.56	5.57
T_5 - Chemical weeding	1.37	7.24	2.92	7.89
T_6 - Cattle grazing	3.68	3.58	3.41	5.28
Significance	ns	*	ns	*
LSD (P=0.05)	-	1.88	-	1.1

The experiment is being continued.

S H S Senarathne, K C P Perera, M J I Costa, B Perera & Y M Chandrasiri

Experiment 5.2. **Effect of different combinations of herbicides on weed control in coconut nurseries and growth of coconut seedlings**

5.2.1. Coconut Cultivation Board Nursery - Wilpotha (IL_1)

Treatments shown in Figure 1 were laid on RCBD with three replicates. Forty seed nuts were established in each plot of which 92% germinated. The major weed species present in this site were Atawara (*Panicum repens*), Nidikumba (*Mimosa pudica*), Kuweni (*Cenchrus echinatus*), Kurunegala Desi (*Tridax procumbens*) and Gandapana (*Hyptis suaveolens*). Treatments were applied according to the schedule. Glyphosate and Diuron treatments applied plots controlled weeds successfully; hence weed biomass of those plots was the lowest (Figure 1). There were no significant differences of weed biomass between T_2 and T_3 treatments.

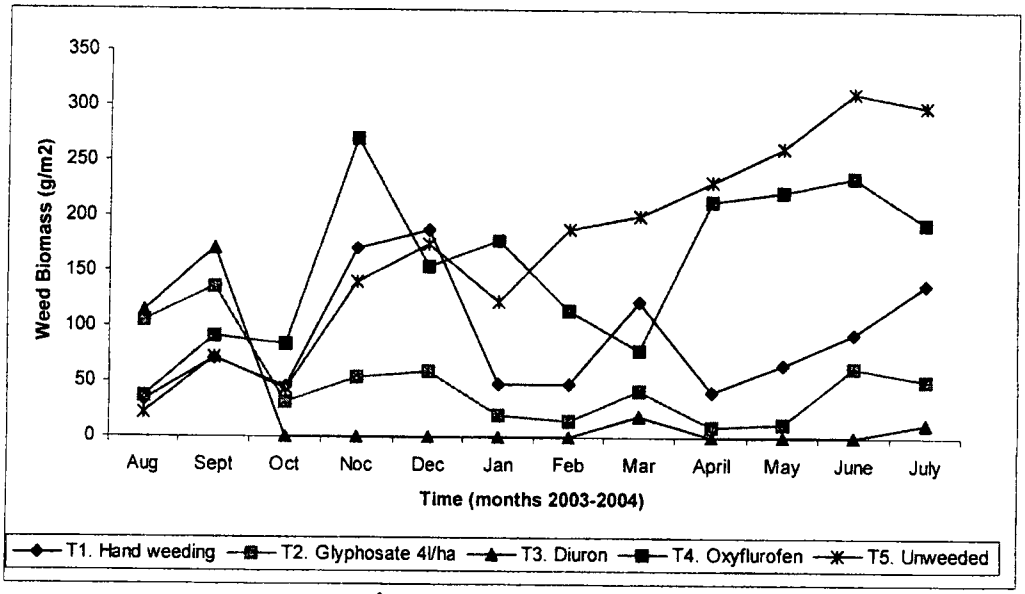

Figure 1. *Weed biomass (g/m^2) in five different weed management methods from August 2003 to July 2004.*

Treatments were applied in October 2003, January 2004 and April 2004.

Table 10: *Effect of different weed control treatments on the growth of coconut seedlings (expressed as the seedling girth (cm)) at Wilpotha*

Treatments	Nov 03	Dec 03	Jan 04	Feb 04	Mar 04	April 04	May 04	June 04	July 04
T1- Hand weeding	7.0	7.7	9.2	10.0	10.6	12.0	12.6	13.5	13.8
T2- Glyphosate 1.40 kg/h	8.1	8.7	10.0	11.1	11.6	13.4	14.2	15.9	16.4
T3- Diuron 3.2 kg ai/ha	7.1	8.0	9.5	10.4	11.2	12.6	13.6	15.8	17.2
T4-Oxyflurofen 0.27 kg ai/ha	7.8	8.2	9.3	10.1	10.7	11.7	12.3	13.2	13.1
T5- Unweeded control	7.8	8.4	95	10.4	10.9	12.2	12.9	13.5	14.1
Significance	ns	ns	ns	ns	ns	ns	ns	**	**
LSD (P=0.05)								1.16	1.15
CV%									

Table 11: *Effect of different weed control treatments on the growth of coconut seedlings (expressed as the seedling height (cm) at Wilpotha*

Treatment	Nov 03	Dec 03	Jan 04	Feb 04	Mar 04	April 04	May 04	June 04	July 04
T1- Hand weeding	50.1	60.5	74.3	81.2	84.1	90.9	101.5	113.5	116.0
T2- Glyphosate 1.40 kg/h	66.6	76.7	92.8	99.8	106.0	113.4	129.5	146.9	150.6
T3- Diuron 3.2 kg ai/ha	48.4	63.4	80.0	80.2	85.0	94.8	109.1	122.7	127.7
T4-Oxyflurofen0.27kg ai/ha	59.4	71.7	84.9	91.6	98.7	106.6	116.4	127.7	125.7
T5- Unweeded control	60.8	74.0	85.4	95.1	99.4	106.6	116.7	130.5	130.0
Significance	ns	ns	ns	ns	ns	ns	ns	ns	**
LSD (P=0.05)									18.5
CV%									

Growth of coconut seedlings as expressed by the seedling girth (cm) and seedling height (cm) was measured. Both growth parameters were significantly different at the end of nursery period. Coconut seedling in Diuron treated plots (T_3) showed higher seedling girth than in the other treatments (Table 10). Unweeded and Glyphosate treatments plots showed higher growth rate (seedling height) than that the other treatments (Table 11).

The experiment was terminated.

S H S Senarathne, K C P Perera & B Perera

PROJECT 19: SMALLHOLDER COCONUT FARMING SYSTEMS WITH ANNUAL/PERENNIAL CROPS IN THE INTERMEDIATE AND THE DRY ZONE

Experiment 19.3: Evaluation of the performance of grafted cashew under coconut

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

Treatments given in Table 12 were tested on a RCBD with three replicates. Each plot consisted of nine effective coconut palms.

During the year, cashew yield in all treatments increased compared to the previous year (Table 12). Bud-grafted cashew produced the highest yield while seedling cashew showed the lowest yield indicating the superiority of bud-grafted over seedling cashew. However, the differences were not significant.

Coconut yield was not affected by intercropping with any of the above three types of cashew trees as was observed in previous years (Table 13).

Table 12: *Performance of different plant types of cashew*

Treatments	Cashew yield	
	Number of seeds per tree	Total seed weight (kg)
Bud grafted cashew	311	2.6
Air-layered cashew	358	2.3
Seedling cashew	208	1.9
Significance (P=0.05)	n.s.	n.s.

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

Treatments	Coconut yield (nuts/palm/year)	
	2003	2004
Coconut monoculture	65	79
Bud grafted cashew	61	75
Air-layered cashew	55	70
Seedling cashew	60	67
Significance (P=0.05)	n.s.	n.s.

The experiment is being continued.

H A J Gunathilake & H A Abeysoma

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

In year 2003, seedling cashew started flowering and produced cashew nuts to yield about 0.03 kg per tree. Bud-grafted cashew yield was the highest among three types of planting materials having 0.3 kg per tree followed by air-layered type with 0.04 kg per tree. However, both types had very low cashew yields compared to the previous year.

Intercropping cashew did not show any significant effect on coconut yield as was observed in the previous year (Table 14).

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

Treatments	Coconut yield (nuts/palm/year)			Cashew yield (kg/tree/year)
	2000-2001	2002	2003	
Coconut monoculture	53	43	66	-
Bud grafted cashew	56	56	72	0.30
Air-layered cashew	53	52	68	0.04
Seedling cashew	50	49	69	0.03
Significance (P=0.05)		n.s	n.s.	

The experiments are being continued.

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PROEJCT 21 : DEVELOPMENT OF SMALLHOLDER COCONUT FARMING SYSTEMS WITH LIVESTOCK (CATTLE AND SMALL RUMINENTS) INTEGRATION IN THE INTERMEDIATE AND DRY ZONE

Experiment 21.4.2: Buffalo grazing as a means of weed control in coconut lands - Makandura Seed Garden (WL_3/S_3) - 1998

This experiment was on a Randomized Complete Block Design (RCBD) with three replicates and 16 effective palms per plot. Three treatments assigned to manage ground pasture and weed cover were, (a) slashing by rotary-slasher attached to a four wheel tractor (3 times per year), (b) *Pueraria* cover cropping and (c) buffalo management (one animal for every 2.0 ha) with rotational grazing at one months cycle.

In year 2003, all experimental plots showed an increased nut production compared to the previous year (Table 15). The nut yield of palms in buffalo grazing plots was significantly higher than that of cover cropping and slashing treatments. However, the difference in nut yield of palms in plots with latter two treatments was not significant.

Table 15: *The effect of buffalo grazing, cover cropping and slashing on yield of coconut at Makandura*

Treatments	Coconut yield (nuts/palm/year)		
	1999-2001	2002	2003
Slashing	81	65	91
Cover cropping	76	51	93
Buffalo gazing	86	69	112
Significance		*	*
LSD (P=0.05)		6	13

The experiment is being continued.

H A J Gunathilake, S H S Senarathne & K D D Appuhamy

PROJECT 25: STUDIES ON CURRENT ECONOMIC ISSUES

Study 25.1: Change in area under coconuts within two decades (1982-2002)

After two decades of the last agriculture Census in 1982, the latest Agriculture Census was carried out by the Department of Census and Statistics (DCS) in 2002. Of the latter survey, the DCS has published the statistics of coconut cultivation in Sri Lanka.

These data was analysed employing simple percentage calculations. The results revealed that the total land area under coconuts in Sri Lanka was 416 235 ha in 1982, which has reduced to 394 836 ha in 2002, representing a 5% (21 417 ha) reduction. The equivalent annual rate of coconut land loss is therefore 1 071 ha/2 645 ac. The coconut land area lost and gained during the two decades were 49 210 ha and 27 793 ha respectively, net effect being reduction of 21417 ha. In 1982, Gampaha district was the second largest coconut district in terms of land area under coconuts, but in 2002 this district has shifted to the third place because of rapid loosing of coconut lands due to fragmentation. Among

the 24 districts[1], 11 districts, namely Gampaha, Kegalla, Colombo, Kalutara, Mannar, Puttlam, Kurunegala, Galle, Kandy, Jaffna and Batticaloa were net loosers of coconut lands while the remaining 13 districts i.e. Badulla, Monaragala, Polonnaruwa, Vauniya, Matale, Hambantota, Matara, Rathnapura, Anuradapura, Nuwara Eliya, Trincomalee, Ampara and Mulative were net gainers. The biggest looser of coconut lands was Kurunegala district (15 536 ha), followed by Gampaha (13 919 ha) and Puttalam (5 693 ha). The smallest looser was Mannar (271 ha). The biggest net gainer was Anuradhapura (8 407 ha). Land area under coconuts both in smallholders as well as estate sector has simultaneously increased in Anuradhapura, Moneragala, Polonnaruwa and Nuwara Eliya districts.

These findings suggest that some districts have lost coconut lands while some districts have newly planted coconut although the former area is bigger than the latter, resulting in a net loss of coconut area in the country. Therefore, this would negatively affect the national coconut production and hence a strategic approach to hit the 3 billion national annual coconut production would potentially include: a) minimizing, not complete seizure, the fragmentation of high potential coconut lands, b) Expansion of coconut in non-traditional areas as much as possible, c) increase the coconut production in lands which currently provide a less than optimal production and d) launching a rigorous home garden coconut cultivation program.

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PROJECT 26: ECONOMIC STUDIES ON MARKETING ISSUES

Study 26.1: Export demand of coir fibre and coir fibre products in Sri Lanka: Implications for export promotion

Sri Lanka continued to be the world market leader in exports of brown coir fibre and coir fibre products only until 1999, after which India took over. During 1992 – 2001, Sri Lankan share of coir fibre and coir products in the world market has decreased from 66% to 43%. With this background, this study investigated the factors affecting the export demand of two types of coir fibre (mattress and bristle) and three intermediary coir products (twisted fibre, coir yarn and twine), with the purpose of discerning appropriate strategies to promote their exports.

Derived demand functions were estimated for each coir fibre and intermediary coir products using a time series of data from 1980 to 2000, employing the ordinary least square (OLS) procedure.

The generic model is as fallows.

$EQ_i = f\ (OP_i, SP, PP_j, CP_{t-1}, Y_{it})$

Where;

EQ_i = Export quantity of i^{th} coir fibre or intermediary coir product
(i = mattress fibre or bristle fibre or twisted fibre or coir yarn or coir twine)

OP_i = Deflated export price of i^{th} coir fibre or intermediate coir product (Rs/ton)
(i = same as above)

SP = Deflated world price of substitute input which is sisal for all four equations (Rs/ton)

PP_j = Deflated export price of j^{th} product made using coir fibre or intermediate coir products (Rs/ton)
(j = mattress bedding or brush or coir matting or ropes)

CP_{t-1} = One-year lagged national coconut production (million coconuts)

Y_{it} = Time trend of exports of i^{th} coir fibre or intermediate coir product at t^{th} time (tons)
(i = as above, t = 1 to 21)

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1 Although Jaffna district has been separated into two districts, as Jaffna and Kilinochchi, we considered these two as a one district for the comparison because they were not separated in 1982.

Linear, double log, Lin-log and Log-lin functional forms were tested and the appropriate form for each coir fibre/intermediate coir product was selected. Results are summarised in Table 16 and 17.

Table 16 : *Factors affecting exports of coir and intermediary coir products from Sri Lanka*

Coir/Intermediary coir product	Factors significant at 5% level
Mattress fibre	Price of product (mattress bedding) (0.0248)
	Coconut production (0.0384)
	Time trend (-0.0398)
Bristle fibre	Price of substitute (sisal)(-0.2953)
	Price of product (brush)(0.1931)
	Coconut production
	Time trend (-0.4206)
Twisted fibre	All variables are insignificant
Coir yarn	Time trend (-0.1007)

Note: Values in parentheses are elasticities at mean.

Mattress Fibre

Price of mattress beddings, a major product made using mattress fibre, and the national coconut production showed a significant positive influence on the export demand of mattress fibre (Table 16). So, market promotion of mattress bedding in the global market place would be an appropriate strategy to promote the exports of mattress fibre. However, synthetic bedding exerts a stiff competition as they come in a wide range of exciting finishes with relatively low prices. Therefore, it is imperative to exploit such attributes as biodegradability and naturalness of coir mattress bedding to launch the market promotion campaign.

Interestingly, export of mattress fibre is more, albeit marginally more, responsive to national coconut production than to the price of mattress bedding (Table 16).

Implicit of this finding is that the measures to increase the national coconut production would have a grater influence in promoting the exports of mattress fibre than the market promotion of mattress bedding. The reason for this is because the full benefits of the market promotion of mattress bedding could not be realised when the national production of mattress fibre is constrained by the raw material (husks) supply shortage arising from depressed national crops.

Bristle Fibre

The significant positive influence of product price (coir brush) on export performance of bristle fibre implies that the price prospects for coir brushes can be used to stimulate the bristle fibre exports. One-year lag national coconut production is also important for the same reason as discussed under mattress fibre.

Table 17 presents the export price elasticities of demand of coir and intermediate coir products.

Table 17: *Export price elasticities of demand of coir fibres and intermediate coir products*

Coir/ Intermediate coir product	Export price elasticity of demand
Mattress fibre	-0.0913
Bristle fibre	0.0042 (positive sign is theoretically unexpected)
Twisted fibre	-0.0240
Coir yarn	-0.0459*

Note: * - significant at 10% level.

Export price elasticities of demand were not significant in any of the coir/intermediate coir products analysed (Table 17). This may be because other factors determine the export volumes of them.

Interestingly, the export price elasticity of demand of all four types of coir/intermediate coir products were inelastic and the values were relatively very small. This implies that the export demand is less responsive to export price changes. However, the national coconut production and the prices of final products showed a positive effect on the exports of coir and intermediate products. Therefore, development of new products and implementing programs to boost national coconut production are recommended for export promotion of coir fibre and intermediate products.

Sri Lanka should not however attempt to export coir in the form of raw fibre, but should attempt to export either as semi-finished products or finished products.

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PROJECT 29: STUDIES ON SOCIO ECONOMIC IMPACTS OF COCONUT SECTOR DUE TO CLIMATE CHANGE

Study 29.1: Economic value of climate variability on coconut industry in Sri Lanka

Coconut is almost exclusively grown as a rain fed crop in Sri Lanka. Rainfall and temperature are the important climatic factors influencing the coconut yield and hence the national coconut production. Although the influence of climate variability on coconut production has been quantified, its economic value has not been estimated, which is the objective of this study. First, the climate extreme years were identified, using 1971 to 2001 national coconut production data, employing percentile analysis and then a simple estimate of economic value of climate variability on coconut production was carried out.

1). Identification of extreme years

During 1971 to 2001 (31 years), national coconut production varied from 1821 million nuts (minimum) to 3096 million nuts (maximum) with a mean of 2 435.90 million nuts (cv= 14%). The lower and upper bounds of extreme production years were assumed respectively as 10% and 90% percentiles of the production array. Based on percentile analysis, the extreme production years were identified (Table 18).

Table 18: *Extreme production years resulted from the percentile analysis*

Percentile	Production extreme	Million nuts	Extreme years
10%	Shortage	< 1948	1973, 1977, 1984, 1988
90%	Glut	> 2828	1985, 1986, 1999, 2000

2). Valuation of first order climate impacts on coconut industry

The immediate effect due to variability of rainfall involves the decrease/increase in national coconut production, which we call as the first order effect, the impact of first order effect being negative and positive respectively in the lower and upper production extremes.

The departures of production in each year of the lower and upper production extreme years with respect to the mean production of the 10% to 90% percentile (which is 2432 million nuts), were computed as shown in Table 19. These production departures would not be attributed solely to climate variability, because the changes in other factors such as fertilizer use, level of technology adoption, management etc. would also intervene. The effect of the latter factors could be crudely excluded by considering that only a 60 per cent of the production departures in Table 19 are due to the climate variability because it has been found that 60 per cent of the variation of coconut production is explained by climate. The 60 per cent of the production departures were then multiplied by free on board (F.O.B) prices of coconuts to derive the foregone/additional economic values to the economy in nominal terms.

Table 19: *Departures of coconut production from the mean in extreme years and their economic values*

Production extreme	Corresponding year	Production (million nuts)	Change in production (million nuts) wrpt* mean production - A	60% of column "A"	F.O.B** price (Rs/nut)	Foregone/incremental Value (Rs million)
Shortage	1973	1948	484	290.4	0.68	197 (32)
	1977	1821	611	366.6	1.15***	422 (49)
	1984	1942	490	294	6.48	1905 (73)
	1988	1937	495	297	5.82	1728 (54)
Glut	1985	2958	526	315.6	3.59	1133 (42)
	1986	3039	607	364.2	3.50	1275 (46)
	1999	2828	396	237.6	17.61	4184 (59)
	2000	3096	664	398.4	16.57	6601 (87)

Notes: *- with respect to.
**- Free on board.
*** - No shipments of fresh nuts were allowed in 1977, but we approximated the f.o.b. in 1976.
n.a. – not available.
1 US $ = approx. Rs 105.00 as of 20 December 2004.
Figures in parentheses are million US $.

Table 19 shows that the foregone income to the economy in crop shortage extremes varied between Rs 197 million to Rs 1 905 million while the additional income accrued in crop glut extreme varied between Rs 1 133 million to Rs 6 601 million, all figures in nominal terms.

These findings imply that the incremental public expenditure on climate adaptation strategies on coconuts such as supplementary irrigation, moisture conservation etc. even to tune of Rs 6601 million per annum would be economical and hence justifiable.

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3. RESEARCH PROJECTS FUNDED BY OUTSIDE AGENCIES

3.1 Coconut-based adaptive research program (under the Second Perennial Crop Development Project, funded by the Asian Development Bank)

By the end of year 2004, the total number of adaptive research sites reduced to 96 with the termination of 16 sites due to poor participation of farmers. Data on coconut and perennial crop yields, soil and other agronomic characters as well as on socio-economic aspects of the remaining sites were collected during the year. Several perennial intercrops such as pineapple, passion fruit etc. were re-introduced or replaced with other perennials (i.e. pepper) at some sites due to the termination of their life spans.

Results are summarized below.

a. Coconut

Coconut yields have to improve in year 2003 compared to 2002 in almost all the sites. In particular, the yield in one site in Matara district has increased from 30 nuts/palm in year 2001 to 70 nuts/palm in year 2003. Palms were applied with organic manure (poultry manure supplemented with 750 g of MOP) since the beginning of the trial in year 2001.

Adult coconut plantations intercropped with bud-grafted cashew in Hambantota district showed promising results after recovery from the drought that prevailed in year 2001.

In Kalutara district, Tall x Tall coconut variety flowered earlier than San Raman x Tall variety at the age of four years although the flowering time of the latter is usually shorter than the former. In Kegalle district, D x T flowered within three years of planting but T x T appeared to have taken some more years for flowering.

b. Banana

In Gampaha district, establishment cost of a one acre banana under coconut was found to be about Rs. 9,500 and the net income obtained during first three years was about Rs. 57,500 per acre. Therefore, intercropping of banana with coconut in wet areas proved to be promising farm model to the grower.

c. Pineapple

Among the selected intercrops, pineapple appeared to be the most popular intercrop owing to its higher returns, high market demand and ability to withstand adverse weather conditions. Use of drip irrigation system for pineapple intercropped with coconut also showed satisfactory results. Lack of coir dust, which is used as a mulch for pineapple cultivation, was identified as one of the main constraints for a successful production, particularly in intermediate and dry zones.

d. Cinnamon

In several sites of the Southern province, the average yield of cinnamon was about 130kg/acre/year at the age of 4 years of planting. Yield and growth performance of cinnamon established in Kegalle and Gampaha districts proved to be promising although the market facilities were not appealing as in the Southern province. Planting cinnamon at 4 x 2 feet spacing seemed better than planting at 4 x 3 feet spacing.

e. Pepper

Although coconut growers seem reluctant to intercrop pepper because of the long delay in getting the income, those who already intercropped would like to continue the practice because of the low input and maintenance cost after three years of planting. However, in year 2003, the market price of pepper declined from Rs. 250 per kg to Rs. 150 per kg.

f. Rambutan

In Kalutara district, Rambutan intercropped with coconut gave promising yields with early flowering. In general, Rambutan performed well in clay loamy soils than in Boralu soils. However, the yielding pattern in different agro-ecological regions varied dramatically due to changes in rainfall pattern.

g. Passion fruit

Growth performance of passion fruit intercropped with coconut appeared satisfactory in Galle, Gampaha, Kalutara and Rathnapura districts. However, the fruit yield was below the average (6 kg/vine/year) and because of this the maintenance cost exceeded its income during the year. Hence, farmers were encouraged to utilize family labour instead of hired labour in certain areas.

Technology transfer activities were also carried out during the year under this project. A training workshop on coconut cultivation and intercropping was held at CRI on 11 and 12 September 2003 for adaptive trial farmers from Gampaha, Kurunegala, Kegalle and Kalutara districts. In addition, two field days were conducted in Gampaha and Kurunegala districts.

The project is being continued.

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3.1 Fuel Wood Plantation Project : Pallama Seed Garden, 1998 (IL_1/S_5) - CESS Project

A fuel wood plantation with Gliricidia and Acacia has been established to study the potential of producing fuel woods in coconut lands for dendro-thermal power generation. Coconut lands categorized as S_4 and S_5 are the most suitable for planting NFT's and this will generate an additional income to the grower.

At present, fuel wood plantation covers 18 hectares with 30,000 and 5,000 gliricidia and acacia trees respectively. The production details are given in Table 20.

The total marketable wood yield has increased by about three folds compared to year 2002 and 133,246 kg of gliricidia sold to Haycarb Ltd. at the rate of Rs. 2.00 per 1 kg at 20% moisture level. The increase in net profit is about 20% compared to the previous year.

0Table 20: *Production details of fuel wood plantation, Pallama Seed Garden*

Description	
Number of harvests during the year	2
Wood yield per tree/yr	17.7 kg
Total wood yield	133, 246.5 kg
Total income (@ Rs. 2.00 per kg)	Rs. 266, 493.00
Total expenditure	Rs. 231, 425.00
Net profit	Rs. 35, 068.00

The project is being continued

H A J Gunathilake & H G Wasantha

3.2 Development of sustainable coconut-based income generating technologies in poor rural communities - ADB Project

The project on " Poverty Reduction in Coconut Growing Communities" (Funded by Asian Development Bank) was implemented in three sites in Sri Lanka with the objectives of enhancing the income of resource poor coconut-based rural communities through sustainable coconut-based interventions; specifically, through the production of high value products, intercropping and livestock farming.

The implementation of project activities were done through the community based organizations i.e. TEDS (*Ththtiripitigama* Entrepreneurship Development Society), WSE (Women's Savings Effort) and DWC (*Dodanduwa* Women's Collective). The memberships of these three CBOs are 420, 200 and 160 respectively in DWC, WSE and TEDS.

Marketable products, that can generate the income for these communities were identified from market surveys in the respective communities. Thereafter trainings were arranged accordingly. To date, 1006 men and women were trained, of whom more than 75% are women. Trainings include, leadership building, micro financing, entrepreneurship, coconut high value products, intercropping and livestock farming, coconut nursery management etc. In order to enhance the access to the borrowing capital for investments, which had been identified as a limitation for income generation through cottage industries, micro credit systems were introduced for these communities through CBOs.

The three communities, have engaged in the production of coconut-based high value products such as coco shell handicrafts, fibre (yarns, doormat, brushes), ekel (brooms), kernel (virgin oil, white copra sweets, crude oil, soap), coconut water (venigar), sap (treacle), bracts handicrafts under the patronage of the "Poverty Reduction Project".

In addition, the introduction of coconut-based livestock systems (poultry, quills, goat, cattle) and intercropping have generated the income. Poultry has been identified as the most effective livestock intervention to generate income; hence an incubator each has been installed in each community to loan out chicks among farmers. Production of value added milk products has shown a promising progress in one community (TEDS).

Marketing campaigns were launched to open market avenues for the communities, with the help of NGOs (Voluntary Services Overseas- VSO, *Siyath*). Two fair trade organizations (i.e. NGOs: *Siyath* Foundation and Gospel House) assisted the marketing of products in the foreign markets. Two communities were able to secure regular export orders for products such as doormats and coconut shell handicrafts. Training on designing, pricing and marketing of coconut-based handicrafts has been conducted.

Baseline survey conducted to ascertain the impact of project interventions showed that income generated by the respondents has significantly improved after the project. Having impressed from the income earned from different activities, most of the members who started in small scale, are expanding their enterprises.

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3.4 Improvement of productivity of coconut soils through vermiculture technology - CARP Project

The CARP funded project on "Development of Vermi-composting System in Coconut Plantations" showed a promising potential of adapting this technology to recycle waste biomass in coconut lands. Waste biomass can be converted into compost within 4-5 weeks with the mediation of worms. Application of vermi-compost and vermi-extract enhanced the growth of coconut seedlings. This technology is going to be introduced to the CRI estates.

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Study 3.5: ***Women's income generation from Coconut–based cottage activities and its contribution to their food security in two rural poor communities in Sri Lanka***

This study focuses on the Women's income generation from two specific coconut–based cottage activities, i.e. coir yarn spinning and bract handicraft making and its contribution to their food security in a sample of women in two selected rural communities in Sri Lanka. To realize the objectives, two equations explaining the women's proportion of income generation and their daily caloric intake were established and econometrically estimated.

The results revealed that the annual average per capita income in the sample is much below the national average of Rs. 90,244 (Central Bank, 2003). The women's daily income has significantly and positively associated with the proportional income contribution they made to the total. Women's age shows a significant positive relationship with the proportion of income generation from the coconut-based activities. Women's total working time on these activities positively and significantly associated with their proportion of income contribution. As these are cottage activities, women in the sample found more time to engage with these two income generation activities after finishing their household chores. There is a significant difference in income generation between the women who got a formal training and those who did. Hence, giving the formal training on these coconut-based cottage activities is a good strategy to enhance their capabilities in production and thereby to assist them to fairly good income, while encouraging the younger generation to engage in these non-farm activities for income generation.

The average food expenditure as a percentage of the total household expenditure was found to be 52 per cent. Results revealed that only the women group in the age category 18-30, get sufficient amount of daily energy intake, whereas the average availability of kilocalories per head per day is below the recommended level by the WHO for the other two groups of women in the sample.

Table 21: *Average daily caloric intake by women*

Women's age group (Years)	Recommended daily caloric intake for women of moderate activity (kilocalories per day)	Women's average daily caloric intake in the sample (kilocalories per day)	Proportion of Calorie contribution from coconuts (kilocalories per day)
18-30	2 100	2 238	27%
30-60	2 150	1 910	25%
>60	1 950	1 693	31%

The women's age shows a significant negative relationship with the daily caloric consumption in the sample, indicating that the older women are more prone to food energy deficits than required. The women's daily caloric intake is significantly associated with their daily income generation in this sample. This implies that the higher the income generated from these coconut-based cottage industries, higher the food security for these poor women. The results revealed that the women's total working time is not a significant variable to determine their daily food energy intake. However, when the total number of members in the household increases, women's daily caloric intake tends to reduce significantly. When there is higher expenditure on food, higher the food energy intake for these women. Also, the coconut's contribution to these rural poor women's daily food energy intake has become a significant variable and consistent with the preliminary results of the survey. Hence, coconuts are not only a source of income but also an important energy source for the rural women in these two communities.

This study was carried out as a component of the ADB poverty reduction project coordinated by the IPGRI. A paper was presented at the International conference to mark the 75th Anniversary of the Coconut Research Institute of Sri Lanka.

S R Samarajeewa & A D Samarajeewa

3.6 The physical performance and functional efficiency of the coconut marketing system in Sri Lanka - CARP Project

This study evaluated the physical performance and the functional structures of the existing coconut marketing system for fresh coconut, desiccated coconut and copra industries, focusing on the three major coconut- producing districts, i.e., Kurunegala, Puttlam and Gampaha. A baseline survey, participating different marketing agents of the coconut market channel was done to collect the relevant information coupled with regular price monitoring process throughout a 12 months period.

The major findings of the study show there are clear differences in nut disposal intervals between smallholders and estate owners. A majority of smallholders and estate owners have regular buyers maintaining their partnership over 3 years period.

Generally the estates in the sample perform poorly resulting in a lower productivity than the smallholder lands. A majority of the smallholders in the sample sells their nuts through middlemen creating lengthy channels, while a majority of estate owners practice direct selling of their nuts for desiccated coconut/copra mills or direct disposing to brokers. The number of middlemen in the channel is vary from 1-2 to 8-10, until the nut reaches it's final destination. None of the growers have forward contracts to sell their coconuts.

The smallholder growers, who are located within a 20 km radius to the copra mill, were found to be the major group of raw material suppliers to the copra millers. The bigger copra mills who need to have a large number of raw material suppliers, which could be around 400. Seasoned coconut without husk is their major raw material. Middlemen and estate owners are the major suppliers for desiccated coconut mills, while brokers and some smallholders are included in their supply list. The number of suppliers to desiccated coconut mills varies from 5 to over 960 as in the case for mills operated by cooperative societies, but all within a 40 km distance to the mill.

The middle dealers are the key players in the channel, in handling, delivering and distributing coconuts into the marketing system. They present in varying capacities and numbers. There are several categories of middle dealers in a typical coconut-marketing channel, i.e primary collectors, middle level collectors, brokers, wholesalers, retailers and exporters. The number of coconut suppliers per middle dealers varies from one to more than 100. The average transport and handling cost for middle dealers varies from Rs.0.25-0.40 per nut. The middle dealer decides their buying and selling price for fresh coconut mainly depending on the desiccated coconut and copra prices. Hence, the farm

gate price of coconut is significantly determined by the desiccated coconut and copra prices. The wholesalers are the key group who dispose nuts into the culinary market, while the brokers are the major suppliers for the desiccated coconut mills and for exports.

The retailers, brokers and the wholesalers extract a higher profit margin per nut than the primary collectors and other intermediate buyers. The profit margin extracted by the retailer, who is at the end of the channel accounts over Rs. 2 per nut. Overall, all the intermediaries in the channel extract more than Rs. 0.5 per nut at each level. Thus, the coconut producer only gets 67% of the consumer price for a coconut he shells into the system. Therefore, 33% or 1/3 of the consumers' price of the coconut is distributed among the middlemen in the system. There is a significant difference between the farm gate prices obtained by the smallholders and the state owners in the Kurunagala district.

The provisional coconut auctions can be considered as a corrective measures to lessen the number of intermediaries involved in the marketing system and to shorten the marketing channels, which benefit the two ends of the system; the produce and the consumer. The need for forward contracts might not have been grasped by the marketing agents in the coconut marketing system, for efficient running of the channel throughout the year, while it may benefit the coconut producers and the consumers in Sri Lanka.

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Study 3.7: Income generation from alternative coconut-based high value products and their profitability in rural poor communities in Sri Lanka

The objectives of this study are to investigate the profitability of selected coconut-based high value production strategies introduced by the poverty reduction project implemented by the Coconut Research Institute in selected coconut-based rural communities in Sri Lanka. Data on all costs and incomes incurred on selected high value productions were collected by interviewing the relevant participants. The gross margin analyses were performed to evaluate the profitability of each selected activity at the field level. Following are several coconut-based high value products initiated through the intervention of the project. i) Door mats, ii) Brooms and ekel brooms, iii) brushes, vi) Virgin coconut oil, vii) Coconut water vinegar, viii) Soap, ix) Coconut sweets, x) Coconut treacle, xi) Coconut husk chip production.

According to the data on gross margin analysis, almost all the selected coconut-based high value product manufacture is profitable to the producers. The incomes generated through these activities are significantly higher, making a sustainable livelihood for many poor people who show their willingness to carry out them through the assistance given by the project. Also, the favourable market options available for these new coconut–based high value products is another advantage for them to make a notably higher income, which was not possible through traditional coconut-based product manufacture that they were engaged earlier. Hence, the project's interventions in these communities to resolve some of these issues with appropriate strategies that fit well these rural poor coconut-based communities and thereby assist these people to upgrade their living standards by reducing their existing poverty level.

Table22: *Summery of profitability of different coconut-based high value products*

Coconut-based high value product	Unit	*Profitability (Net profit per unit)*	*Average net income*
Coconut water vinegar	1 liter	47.65/liter	Rs.47.65/liter of vinegar(500 coconut generate 72 liters of nut water)
"Thawashi" brushes (26 cm length)	1 brush (26 cm)	0.58/brush	Rs.101.05/man day (@ 175 brushes / man day)
Husk chips	1 kg	0.73/kg	Rs.950.00/man day (@2000 kg chips/man day)
Coconut Shell owl	1 owl piece	230.00/piece	Rs.460.00/man day (@ 3 shell owls/1.5man day)
Coconut bract file bag	1 file bag	317.00/file bag	Rs.317.00/man day(@1 file bag/man day)
Virgin Coconut oil	1 liter	86.50/liter	Rs.908.35/man day (@ 10.5 liters/man day)
Coconut ekel broom	1 piece	11.20/broom	Rs.560.00/man day (@ 50 ekel brooms/man day)
Coconut Toddy	1 liter	3.40/liter	Rs.3060.00/palm/year (@ 900liters/palm)
Coconut Treacle	1 liter	47.10/liter	Rs.141.30/man day (@ liters/man day)

Note: Only the variable costs were considered for profitability analysis.
Incomes were calculated assuming that there were no marketing constraints for there products.

This study was carried out as a component of the ADB poverty reduction project coordinated by the IPGRI. The full paper was presented at the International conference to mark the 75th Anniversary of the Coconut Research Institute of Sri Lanka.

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4. Miscellaneous Studies

4.1 Demonstration farm, Thabbowa, Nattandiya

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

During the year, 15,288 coconut seedlings worth of Rs. 418,988.00 were issued. The farm had a net profit of Rs. 186,445.17 in year 2004 (Table 23).

Table 23: *Annual income and expenditure of demonstration farm, Thabbowa*

Income			Expenditure	
Item	Quantity Nuts/Seedlings	Value Rs.	Item	Value Rs.
a. Sale of coconut	31631	311,376.00	a. Labour	319,210.96
b. Sale of coconut seedlings			b. Others	9,979.00
			c. Materials	60,886.10
Poly bagged T x T	663	43,815.00	d. Electricity	15,695.00
D x T	340	20,400.00	e. Seed nuts	165,834.10
R.D	25	1,530.00		
K.C	153	10,335.00		
Other	60	4,050.00		
Bare rooted T x T	12 061	278,930.00		
D x T	1986	59,908.00		
C. Sale of other crops		27,685.83		
Total Income		758,050.33		571,605.16
Profit:		186,445.17		

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1.2 Animal breeding program

An animal-breeding programme at Ambakelle, Makandura and Pothukulama is being continued to provide improved breeds of buffalo and goats for coconut growers. Details are given below.

Table 24: *Animal breeding program*

Place	Breed	End of 2001		End of 2002		End of 2003	
		F	M	F	M	F	M
Makandura	Moora	16	10	14	15	20	8
PRS	Sri Lankan Boer	21	82	66	20	70	27

H A J Gunathilake & S H S Senarathne

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Awards

The project on " Poverty reduction through coconut-based interventions" won several awards including the best country project. Mr A D Samarajewa of Agronomy Division was awarded as the best country coordinator of the eight countries in which project was implemented.

REPORT OF THE GENETICS AND PLANT BREEDING DIVISION
Head-J M D T Everard (M Sc, Australia)

1. General

The most significant event of the Genetics and Plant Breeding Division in the year 2004 was the release of Kapruwana, the new coconut cultivar derived from the cross between dwarf green x san ramon. Granting registration for 18 private coconut nurseries collaboratively with the Seed Certification Service of the Department of Agriculture, enrichment of coconut germplasm by addition of ten exotic coconut varieties from Ivory Coast, progress made in establishing a mapping population for coconut, establishing a field trial to evaluate the cross, dwarf brown x tall are other noteworthy accomplishments during the year. The on-going long term experiments, genetic evaluation of existing cultivars, progenies and germplasm crosses, establishment of new cultivars in farmer's fields and maintenance of the gene banks were also continued successfully during the year.

Kapruwana, originated from the cross between Sri Lanka dwarf green and san ramon tall, which is a pacific tall coconut variety, was released as a new cultivar after testing over a period of 18 years by the CRI at the Daisy Valley Estate, Mawathagama. Early flowering, and high yielding traits of dwarf green and large nuts and high kernel content (or copra content) traits in san ramon were precisely blended in this new cultivar. 'Kapruwana' has exhibited its potential to flower in 4-5 years, bear in 5-6 years and reach yield stability in 10 years after planting with an yield potential of 12,000 nuts per ha. Nuts on average weigh above 1.8 kg with a copra turn over of 300 grams per nut or 3.75 Mt/ha. This is comparable with all the best coconut hybrids developed so far in the world. 'Kapruwana' has presumably mingled all the best qualities of coconut to qualify as an outstanding coconut hybrid to meet the requirements of both small and large scale growers of coconut in Sri Lanka.

CRI for the first time in the history granted permission for establishment of private nurseries for production of coconut seedlings. Registrations were granted on an agreement signed by CRI and the nursery owner that seedlings should only be raised from seeds provided by CRI and obtain certification for every seedling disposed from the Seed Certification Service of the Department of Agriculture. Among 22 requests received 18 [(Kurunegala 06), Puttalam (07), Matara (01), Matale (01), Polnnnaruwa (01), Anuradhapura (01) and Vauniya (01)] were granted registration.

Enrichment of the coconut germplasm by exotic introductions was further accomplished by collecting 242 embryos of Polynesia tall, 212 embryos of Tagnanan tall, 257 embryos of Vanuatu tall, 42 embryos of Tacunan green dwarf, 292 embryos of Tahitian tall, 351 embryos of Niulekha green dwarf, 65 embryos of Tenga tall, 199 embryos of Malayan red dwarf, 276 embryos of West African tall and 106 embryos of Catigan green dwarf from Ivory Coast. These embryos are now being raised in the Tissue Culture Laboratory of CRI.

Mapping of the coconut genome was envisaged as means of coconut improvement by marker assisted selection. As a pre-requisite towards mapping the genome a pollination programme was initiated for developing a segregating population of coconut using 33 dwarf red coconut palms and a single Sri Lanka tall palm at Bandirippuwa Estate, Lunuwila. This pollination programme was initiated in March 2004. Successful progress was achieved to date with setting of 963 female flowers into immature nuts. Initial framework map is due to be constructed from these and subsequent mapping of QTLs is expected following the establishment of these families in the field.

Field evaluation of a new hybrid, Sri Lanka dwarf brown x Sri Lanka tall was initiated during the year by establishing a field experiment at Raddegoda Estate, Delwita. This experiment was designed as a multilocational trial with the inclusion of the reciprocal of the same cross, dwarf brown x san ramon and CRIC60, CRIC65, CRISL98 and "Kapruwna" as controls. Another block at Ratmalagara Estate, Madampe was identified for establishing the second site.

The long term experiments on genetic evaluation of existing cultivars were continued successfully. In the cultivar evaluation trial inter-varietal hybrids yet again continued to out perform pure tall cultivars in the two sites, Bandirippuwa (BE) and Suriyapura (SE). The hybrid, dwarf green x tall recorded a yield of 12,200 nuts/ha during the year at BE. The respective yields of dwarf yellow x tall, CRIC60, Moorock and Plus Palm were 11,200, 10,000, 8600 and 9400 at the same site. At SE the respective yields of the five cultivars were 13,000, 12,000, 8,000, 8400 and 8,000.

The evaluation of progenies arising from tall x tall, tall x dwarf green and tall x san ramon at Bandirippuwa and Ratmalagara sites were continued and yields were recorded. The performance of tall x dwarf green was once again the best with an annual yield of 11,200 nuts/ha during the year at BE. The corresponding yields of tall x tall and tall x san ramon were 10,600 and 10,000 respectively. Performance of all the three progenies at the Ratmalagara site were better where tall x dwarf green recorded 14,400 nuts/ha while tall x san ramon and tall x tall recorded 12,400 and 12,600 nuts/ha/yr respectively.

In the progeny experiment at Daisy Valley Estate, Mawathagama the performance of dwarf green x san ramon yet again equaled tall x dwarf green in copra productivity. Among the reciprocal crosses tall x dwarf performed better comparing to dwarf x tall both in terms of nut production and copra productivity. Tall x dwarf green was the best with 13,800 nuts/ha (2.98 Copra Mt/ha) followed by dwarf green x tall (12,600 nuts/ha and 2.62 Copra Mt/ha), dwarf green x san ramon (11,800 nuts/ha and 3.02 Copra Mt/ha), tall x san ramon (9,600 nuts/ha and 2.78 Copra Mt/ha) and tall x tall (9,600 nuts/ha and 2.23 Copra Mt/ha).

Establishment of CRISL98 (tall x san ramon) in farmer's fields was continued during the year and 8157 seeds were produced by hand pollination and 2805 seedlings were issued to 20 growers in six districts, Puttalam (7), Kurunegala (5), Gampaha (4), Polonnaruwa (2), Matale (1) and Vavuniya (1). A similar programme was commenced to establish the new release, Kapruwana in farmer's fields. During the year 1,166 seeds were produced by hand pollination and 478 seedlings were issued to three growers in Kurunegala (2) and Puttalam (1) districts.

Conservation of coconut germplasm was continued by maintaining the field gene banks satisfactorily. A new collection was made from Rumassala for conservation as an accession. A total of 26 palms have been identified from the Unawatuna area for in depth investigation and conservation. These are Ran Pol (3), Nawasi (3), Juwan (12), Juwan small (1), Thatin (1), Bothal Thembili (1), Rath Gon Thembili (1), Dothalu (1) and Plus Palms (3).

Increasing the production of CRIC65 for high input coconut farming and home garden planting was recognized and a program was initiated to upgrade Genetic Resources Center at Ambakelle to increase the production of CRIC65. Establishment of a drip irrigation facility for mother (dwarf) palms and converting another tall field into a mixed field is now in progress with the assistance of the CESS fund.

Detailed Report

PROJECT: **EVALUATION OF EXISTING CULTIVARS (1983/86)**

Experiment 12.1.1: **Evaluation of five improved cultivars; dwarf green x tall (CRIC65), dwarf yellow x tall (CRIC65), tall x tall (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	1983	Loamy sand	Wet intermediate
12.1.2	Thammenna	1983	Latasol	Dry
12.1.3	Palugaswewa	1985	Sandy clay loam	Dry intermediate
12.1.4	Suriyapura	1986	Lateritic-gravel	Wet

Yield (nuts/palm) was recorded only at two sites during the year, the sites at Bandirippuwa (BE) and Suriyapura (SE). In both of the sites hybrids, both dwarf green x tall and dwarf yellow x tall yet again continued to outperform pure tall cultivars. The hybrid, dwarf green x tall recorded a yield of 12,200 nuts/ha during the year at BE. The respective yields of dwarf yellow x tall, CRIC60, Moorock and Plus Palm were 11,200, 10,000, 8600 and 9400 at the same site. At SE the respective yields of the five cultivars were 13,000, 12,000, 8,000, 8400 and 8,000. As adequate yield and fruit component data have been collected over a period of 19-22 years from all the trials, it was decided to continue only nut yield recording for sites BE and SE as observational trials. The data collected from all the sites so far will be analyzed collectively in order to obtain accurate and comprehensive information about comparative performance of different varieties, site x variety interaction and varietal response to dry and wet weather.

J M D T Everard, C K Bandaranayake, W B S Fernando, M H L Padmasiri & S Mallawarachchi

PROJECT: ON-FARM EVALUATION OF NEW CULTIVARS

Experiment 12.1.2: Evaluation of CRISL98 (tall x san Ramon) under farmer conditions

Production of CRISL98 (tall x san Ramon) was continued by hand pollinating 100 selected tall palms at ISG with pollen collected and processed from san ramon palms at Bandirippuwa. The seeds were raised at ISG and issued to growers in different agro ecological zones having different soil suitability classes and practicing different management conditions. Initially only one to two-acre small blocks were considered for this programme. A vigorous and fast growth was observed in the previously issued seedlings planted in various places and as a result, a high demand for the new release CRISL98 (tall x san Ramon) was observed. During the year a total of 8157 seed nuts were harvested and 2805 seedlings were issued for planting in six districts among 20 farmers (Puttalam (7), Kurunegala (5), Gampaha (4), Polonnaruwa (2) Matale (1) and Vavuniya (1).

J M D T Everard, S Mallawarachchi & S A Chandrasiri

Experiment 12.1.4: Evaluation of dwarf green x san ramon under farmer conditions

During the year, total of 1166 "Kapruwana" seed nuts were produced by hand pollination of 50 dwarf green palms at ISG. Total of 478 seedlings were issued to three farmers, two in Kurunagala district and one in Puttalam district.

J M D T Everard, S Mallawarachchi & S A Chandrasiri

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)**

The objective of the project was to study the inheritance of drought tolerance trait of coconut through progeny testing. In 1991, a set of palms at the field 4/ISG were selected on the basis of nut size and nut number during an adverse drought and seeds produced by various combinations of paired crosses by hand pollination among selected palms were planted both in field 14 within ISG and at Maduru Oya Seed Garden, where prolong droughts are likely to occur. These families are still maintaining as observation trials until they reach the yield stability to commence nut recording, analysis of fruit components and assessment of water-use-related physiological parameters specially during drought and after wards.

L Perera & M H L Padmasiri

Experiment 12.3: **Crossing of selected palms at ISG with promising germplasm accessions (1993)**

Progeny of four crosses between Ambakelle tall and high yielding germplasm accessions Moorock tall and St Anne's and putative drought tolerant accessions Kasagala tall and Debarayaya tall and Ambakelle special as a control were established in five different locations to test the vigor giving special reference to yield stability and drought tolerance. However, young palms at both Bataatta and Kiulakelle sites succumbed to severe drought and poor management by the land owners and hence these two trials were abandoned during the year. Similarly due to very poor soil depth and soil fertility of the Girtland site, the seedlings in the trials did not come up as expected, resulting in palms with uneven and retarded growth. Hence the site at Girtland was also abandoned from the project. Sites at Melsiripura and Siringapatha were maintained satisfactorily during the year.

L Perera, M H L Padmasiri, W B S Fernando, G K Ekanayake & S Mallawarachchi

Experiment 12.7.3 **Evaluation of dwarf green x Debarayaya tall (Raddegoda)**

Some coconut palms at Debarayaya estate at Thangalle in Hambantota districts had been marked by the then staff of the GPB division, which showed moderate performance, during the severe drought in 1983, when most of the coconut palms and other trees in the area succumbed to death due to drought. Open pollinated seeds of those palms have been collected and conserved *ex-situ* in the coconut gene bank of the CRI, as a putative drought tolerant accession of coconut. Pollen from the original palms were crossed to dwarf greens in order to test and compare the tolerance of this cross with CRIC65 with a view of improved by crossing with putative drought tolerance trait of the Debarayaya palms. A small trial comprising forty-eight seedlings of dwarf green x Debarayaya tall were planted with an equal number of dwarf green x tall (CRIC65) seedlings for comparison purpose at Raddegoda estate Delwita in 1995. Yield data recording from this trial commenced this year and will be continued until the plantation under-go a long and severe drought, making it possible to compare the response of both varieties to water stress.

J.M.D.T. Everard, L Perera & G K Ekanayake

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

Three hybrid crosses namely Cameroon red dwarf x Ambakell tall, Dwarf green x Debarayaya tall and dwarf green x Ambakelle tall, were established at Loling estate Halkandawila, Payagala in May 1997 in order to evaluate the progenies for yield and yield component, and then subsequently for sap production potential. The palms are now at partial bearing stage and hence maintained as an observation trial, without commencing yield records.

J M D T Everard & N Herath

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

Locations and agro ecological conditions of locations

Location	Year of establishment	Soil type	Agro ecological zone
Bandirippuwa	1986	Loamy sand	Wet intermediate zone
Ratmalagara	1986	Lateritic	Dry intermediate zone
Andigama Mudalihamy	1986	Sandy Loam	Dry intermediate zone
Mangala-Eliya[1]	1987	Loamy sands	Dry zone
Daisy Valley[2]	1987	Clay loam	Wet intermediate zone

[1] with Open pollinated tall as additional variety

[2] with DG x T and DG x SR as additional varieties

The evaluation of progenies arising from several combinations of crosses at Bandirippuwa, Ratmalagara and Daisy Valley sites were continued and yields were recorded. Fruit Component analysis was continued only at Daisy valley estate during the year. The performance of tall x dwarf green was once again the best with an annual yield of 11,200 nuts/ha during the year at BE. The corresponding yields of tall x tall and tall x san ramon were 10,600 and 10,000 respectively. Performance of all the three progenies at the Ratmalagara site were better where tall x dwarf green recorded 14,400 nuts/ha while tall x san ramon and tall x tall recorded 12,400 and 12,600 nuts/ha/yr respectively.

Among various progenies at Daisy Valley estate, the reciprocal crosses tall x dwarf performed better compared to dwarf x tall both in terms of nut production and copra productivity. In terms of number of nuts, tall x dwarf green was the best with 13,800 nuts/ha (2.98 Copra Mt/ha) followed by dwarf green x tall (12,600 nuts/ha), dwarf green x san ramon (11,800 nuts/ha), tall x san ramon (9,600 nuts/ha) and tall x tall (9,600 nuts/ha). However, as far as the copra production per unit area is concerned, dwarf green x san ramon and tall x dwarf green were equally best (3.02 and 2.98 Mt/ha respectively) in the first place in the rank, followed by tall x san ramon (2.78 Mt/ha), dwarf green x tall (2.62 Mt/ha), and tall x tall (2.23 Mt/ha) (Table 1).

As a large data set has now been accumulated over a period of 17-18 years including vegetative and reproductive data, a comprehensive data analysis will be carried out next year to generate more information about the varieties under evaluation.

Table 1. *Nut and copra yield of the progenies at Daisy Valley estate (2004)*

Variety	Nuts/palm/Year	Nuts/ha	Copra/nut (g)	Copra/ha (Mt)
T x DG	68	13,800	216	2.98
DG x T	63	12,600	208	2.62
DG x SR	58	11,800	256	3.02
T x SR	48	9,600	290	2.78
T x T	48	9,600	231	2.23

The cross between dwarf green and san ramon was released this year as a new coconut cultivar under the name "Kapruwana", based on 18 years of data collected from the above trial during the 75 Anniversary Celebration of the CRI. Early flowering and high yielding traits of dwarf green and large nuts with high kernel content in san ramon have been well combined in this new cultivar to give the highest copra production among all cultivars. 'Kapruwana' has exhibited its potential to flower in 4-5 years, bear in 5-6 years and reach yield stability in 10 years after planting with an yield potential of 12,000 nuts per ha at the age of 18 years under average management conditions. Nuts of "Kapruwana" weigh above 1.8 kg with a copra turn over of 300 grams per nut or 3.75 Mt/ha on average.

Two observation trials established at Sirikandura (1989) and Ratmalagara (1989) were maintained satisfactorily during the year.

J M D T Everard, N Herath, W B S Fernando & K Ekanayake

PROJECT : EVALUATION OF THE 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

During the year pollination programme was continued to raise seed nuts of dwarf brown x tall and dwarf brown x san ramon using 14 pure dwarf brown palms planted at the Pottukulama Research Station using pollen from Ambakelle tall from ISG and san ramon pollen from Bandirippuwa. Pollination programme to produce the reciprocal hybrids of dwarf brown x tall (tall x dwarf brown) was carried out at the ISG using 30 palms of selected Ambakelle tall using pollen from dwarf brown at Pottukulama Research Station.

The first trial of dwarf brown crosses were established at the Raddegoda estate, Delwita, dwarf green x tall, dwarf green x san ramon, tall x san ramon and tall x tall as control crosses. The total number of seedlings established was 415 comprising 240 seedlings in the trial (36 dwarf brown x tall, 36 tall x dwarf brown, 24 dwarf brown x san ramon, 36 dwarf green x tall, 36 dwarf green x san ramon, 36 tall x san ramon, and 33 tall x tall) and 175 seedlings in the guard rows. Wherever tall x tall and tall x san ramon cultivars, which are tall in stature, are planted in plots next to a medium stature cultivar (dwarf green x tall, dwarf green x san ramon, dwarf brown x tall, dwarf brown x san ramon and tall x brown dwarf), dwarf green x tall hybrid was used as guard row seedlings between them, in order to minimize the possible interference from tall stature trees to medium stature trial trees when they mature. In all blocks in the trial, tall x tall and tall x san ramon plots were planted next to each other in order to minimize the number of guard rows as interactions between tall stature trees are minimum. The trial was established as a Randomized Complete Block Design (RCBD) with four blocks comprising 6-9 palms per plot. There was a proposal to establish next trial at Ratmalagara estate during next year.

L Perera & R Jayathilaka

PROJECT: **COCONUT GENOME MAPPING**

A hand pollination programme to develop a segregating mapping population aiming at construction of coconut genome map subsequently was commenced from March this year. Total of 33 dwarf red palms in the *ex-situ* gene bank at 50ac block at Bandiripuwa estate served as mother palms in this programme, while a single Sri Lankan tall palm, selected from Bandirippuwa estate served as the pollen parent. Total of 241 inflorescences have been pollinated at the end of the year resulting in 963 button setting three months after pollinations. Genotyping of dwarf mother palms using microsatellite markers in order to study their homogeneity is to be done in year 2005.

C.K. Banadaranayake & W B S Fernando

PROJECT: **COLLECTION CONSERVATION AND EVALUATION OF COCONUT GERMPLASM**

Enrichment of coconut germplasm

During the year, ten coconut varieties from Ivory Coast were brought as embryos into the county to enrich the genetic base of the coconut in the country. A Senior Plant Breeder from the CRISL, Dr. Champa Bandaranayake with a Technical Officer from the Tissue Culture division visited Ivory Coast during August this year to identify suitable varieties, and to ensure the phyto-sanitary safety. The name of the varieties and number of embryos collected are given in table 2.

Varieties imported from India are in the hardening stage at the green house and they are expected to be planted in the field in year 2005. Varieties imported from PNG are still in *in-vitro*. Complete details of in-vitro culture of all varieties imported are given in the appropriate section of the Annual Report of the Tissue Culture Division.

Table 2. *Name of the varieties and number of embryos imported from Ivory Coast*

Name of the variety	Variety Code	No. of embryos collected
Polynesia tall	PT	242
Tagnanan tall	TGT	212
Vanuatu tall	VT	257
Tacunan green dwarf	TGD	42
Thahitian tall	TAT	291
Niuleka green dwarf	NGD	315
Tenga tall	TNT	65
Malayan red dwarf	MRD	199
West African tall	WAT	276
Catigan green dwarf	CGD	106

L. Perera

Experiment 12.7.1: Collection of germplasm of the commercial tall variety (Typica typical)

A self pollination programme for purification and multiplication of the varieties ran pol, juwan pol, dothalu pol, thatin pol, bothal thembili, murusi pol and naw pol, that were identified last year as new coconut morpho-types from Unawatuna area in Galle district was commenced early this year resulting in 356 button setting three months after pollination and 41 mature harvested seed nuts. The morphology of these varieties will be studied in more detail in year 2005.

During the year a new collection was done from Rumassala, in Galle and seed nuts were laid at the Bandirippuwa research nursery. Further, nuts were collected from Deegawapi, Damana and Amparai for infilling purposes.

The self-pollination programme for purification and multiplication of indigenous coconut varieties, pora pol, dikiri pol, rathran thembili, ran thembili, bodiri, gon thembili, kamandala and nawasi was continued this year too. It is expected to establish a large conservation block from theses varieties.

The field gene banks at Bandirippuwa, Pottukulama, Lenawa, Margaret estate and Kohombana and Raddegoda were maintained successfully. The Coconut Genetic Resources Database (CGRD) of the COGENT was updated with the progress of rejuvenated germplasm accessions in field gene banks.

J M D T Everard, C K Bandaranayake, R Jayatilaka &K Ekanayake

PROJECT: EVALUATION OF CONSERVED COCONUT GERMPLASM

Experiment B-9: Characterization and evaluation of indigenous Thembili germplasm (1996)

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

C K Bandaranayake, J M D T Everard,
M H L Padmasiri, R B Attanayake & N Herath

OUTSIDE FUNDED PROJECTS

(A) Molecular marker-based characterization of conserved coconut germplasm in national gene bank and selected Farmer's varieties in the IPGRI/COGENT poverty reduction project sites in Sri Lanka (IPGRI funded)

A microsatellite kit comprised of 14 SSR primers developed by CIRAD/France for COGENT/IPGRI was used to generate molecular data from five coconut accessions from Sri Lanka tall (Ambakelle tall, Moorock tall, Clovis tall, St. Anne'stall and Debarayaya tall) and from seven Farmer's varieties (Kumbuke pol, Kadawala pol, and Muhuriya pol from site Wilpotha, Nuwara kelle pol, Tharana pol and Wariya pol from site Hettipola and Dadalla pol from site Dodanduwa). Each Sri Lankan tall accession was represented by 20 palms while each Farmer's variety was represented by 15 palms. In addition, seven Sri Lanka dwarf green variety were also included as a control for the assay. DNA isolation was completed for all varieties and microsatellite data were collected for 11 primer pairs for all samples.

L Perera, W B S Fernando & A Fernando

(B) Diagnosis of Pathogens using molecular tools (CESS funded)

During the year dot-blot hybridization technique was perfected at the molecular biology laboratory, and this technique was used to examine the involvement of Cadang-Cadang viroid in causing the Rapid decline in coconut. Cadang-Cadang positive samples were repeatedly observed using the technique. Though the technique is a powerful tool to detect known pathogens, this could not be considered as a perfect test for confirmation of a pathogen of an unknown disease. Therefore, it was proposed to conduct Southern blotting and RT-PCR to confirm the results before final conclusion is made for Dot-blot technique alone.

L Perera, N Herath & A Fernando

(C) Increase of CRIC65 seed nut production at the ISG (CESS funded)

Two thousand and sixteen dwarf palms were applied with organic manure this year to improve the production level of dwarf palms by improving the soil physical condition and nutrient status. Alternative rows of tall coconut palms at field 11A, which had been planted at high density, were uprooted and seed holes were marked for planting dwarf green seedlings in order to increase the seed production capacity of the ISG, without expanding the seed garden. Arrangement to drip irrigate all dwarf-tall mixed fields were proposed and maps and budget estimates were prepared.

L Perera, J M D T Everard & S A Chandrasiri

(D) Development of DNA- markers for variety identification (IFS/Sweden funded)

This project was successfully completed and the results were presented at the coconut conference held at Colombo August this year to mark the 75th anniversary of the CRI. A marker kit was developed that could distinguish tall, dwarf green, dwarf yellow, dwarf green x tall and dwarf yellow varieties and cultivars.

L Perera, W B S Fernando, A Fernando & N Herath

ESTABLISHMENT OF THE PALLAMA SEED GARDEN

Establishment of Pallama Seed Garden (PSG) for mass production of CRISL98 was continued. Total of 211 san ramon seedlings (22 in field 1, 135 in field 2 and 54 in field 3) and 238 tall x tall seedlings (26 in field 1, 42 in field 2 and 170 in field 3) were planted. Selfing of pure san ramon is in progress for production of san ramon seedlings for planting in PSG in the year 2005 too.

C K Bandaranayake & M H L Padmasiri

PRIVATE NURSERY REGISTRATION PROGRAMME

A workshop on "Production of Tea, Rubber and Coconut seeds and seedlings and soil and leaf analysis – Prospects for private sector participation'" was held at the Hector Kobbekaduwa Agricultural Research and Training Institute, Colombo, on 10 November 2003, organized by the Ministry of Plantation Industries to discuss the ways and means of how private sector participate in the planting materials production activities and other services offered to the plantation sector by the three Research Institutes for Tea, Rubber and Coconut. The workshop was attended a large invited crowd both from public and private sector and was chaired by Mr. K A S Gunasekera, then Secretary of Ministry of Plantation Industries. As a result, CRI granted permission for establishment of private nurseries for production of coconut seedlings this year for the first time in the history in order to initiate a programme for the private sector to participate in the coconut planting materials production activities, which was earlier solely owned by the public sector. However, registrations were granted on an agreement signed by CRI and the nursery owner that seedlings should only be raised from seeds provided and certified by CRI and that certification for every seedling issued from the Seed Certification Service of the Department of Agriculture is obtained. Among 22 requests received 18 [(Kurunegala 06), Puttalam (07), Matara (01), Matale (01), Polnnnaruwa (01), Anuradhapura (01) and Vauniya (01)] were granted registration and seeds were subsequently supplied to them from ISG.

J M D T Everard & S Mallawarachchi

Extension activities

The number of clients who visited the division in search of technical knowledge during the year exceeded five hundred. In addition a substantial number of undergraduates visited the division and the molecular biology laboratory. Special programmes were conducted on Plant Breeding and Plant Molecular Biology for students of the Post Graduate Institute of Science, Faculty of Agriculture of University of Peradeniya and University of Wayamba.

GPB staff engaged in selection and reselection of seed palms for CCB in large number of estates.

REPORT OF THE SOILS AND PLANT NUTRITION DIVISION

Head – N A Tennakoon, PhD

1. GENERAL

In the Soils and Plant Nutrition Division, eleven on going field experiments were continued and two new experiments were commenced in the field level and the other was a pot experiment. The on going deep ground water survey, in the Kurunegala District carried out under Cess Fund was completed in this year. The total research expenditure for research and maintenance was Rs. 2,210,000/- and Rs. 260,000/- respectively.

The experiment on site specific fertilizer recommendation at Mangala Eliya (S_2, DL_3), 34% nut yield increase was observed from the palms receiving 1400 g urea, 1050 g Imported Rock Phosphate, 2800 g Muriate of Potash and 1750 g Dolomite (Treatment 4) over control (no fertilizer) and 15% nut yield increase was observed in the recommended fertilizer treated palms over the control. The difference was statistically significant ($p \leq 0.01$). This year i.e. four years after fertilizer application, this nut yield increase has shown particularly on Borupan series soil in the Dry Zone where the site is located. Increase of urea by 600 g, Imported Rock Phosphate by 450 g, Muriate of Potash by 1200 g and dolomite by 750 g (T_4) have shown the highest nut yield compared to the recommended dose (T_2). The female flowers of the palms at the Kobeigane site (S_3 IL_1, Wariyapola series) have shown a significant increase than the palms receiving the same treatment while in Mangala Eliya (T_4) gave significantly highest nut yield ($p \leq 0.05$).

Drip irrigation experiment conducted at Ratmalagara Estate showed a 32% yield increase compared to control (no irrigation).This increase was observed in the treatment 40 l/palm/day at 6 days interval with 250 g of APM plus 83 g of dolomite at monthly interval per year.

Experiment on comparison of organic and green manure with supplementary application of inorganic fertilizer (APM), showed that the nut yield of the palms receiving poultry manure was increased by 38% compared to that of the control (no fertilizer). While the yield increase by inorganic fertilizer over the control (no fertilizer) was 17%. Among other organic sources such as cattle manure, goat manure and gliricidia, the yield increase was 26%, 21% and 18% over the control respectively. Sixteen percent yield increase was observed in palms receiving poultry manure over inorganic fertilizer (APM). Results indicated that the application of organic manures such as poultry manure, cattle manure, goat manure were more economically beneficial than that of inorganic fertilizers as in the previous years.

Evaluation of sodium chloride as a substitute for potassium chloride (muriate of potash) revealed that although, the yield of potassium chloride treatment was higher than that of sodium chloride, the difference was not statistically significant, but it is too early to make a recommendation. The yield difference between potassium chloride and sodium chloride treatments was 14 nuts/palm/year. It was further observed that yield difference was 15 nuts/palm/year and 1 nut/palm/year for the potassium chloride and control (no fertilizer) and sodium chloride and control (no fertilizer) respectively. Leaf nutrients such as K, Na and Cl have shown significance differences ($p \leq 0.05$) among the treatments.

The experiment on evaluation of the efficiency of different sources of rock phosphates as a fertilizer for coconut growing soils in the Dry Zone revealed that the mean values of P availability were in the order of Triple Super Phosphate (TSP) > Imported Rock Phosphate (IRP) > High Grade Eppawela Rock Phosphate (HERP) > Eppawela Rock Phosphate (ERP) were determined at the one month interval upto one year. This clearly showed that IRP is more beneficial than HERP or ERP to the coconut plantation in Dry Zone.

2. RESEARCH PROJECTS

PROJECT 6.0: SUBSTITUTION OF LOW COST PHOSPHATE (ERP) IN PLACE OF SAPHOS PHOSPHATE FERTILIZER 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, on a Randomized Block Design with 3 replicates and 6 palms per plot, was established in 1991 by planting T x T seedlings on Andigama series soils 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
TSP (46% P_2O_5)	350
IRP (27.5% P_2O_5)	600
ERP (30% P_2O_5)	600
Control (No P source)	0

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

Leaf samples from 14th frond of each treated palm were taken in May 2004. Fertilizer application was carried out in July. Nut yield from February 2004 to January 2005 did not show significant differences among the treatments (Table 2).

Table 2. *Nut yield of the experiment*

Treatment levels	Nut yield (per palm per year) 2002 December to 2003 December	2004 February to 2005 January
TSP	33	53
IRP	35	50
ERP	32	48
Control (No P sources)	27	40
Level of significance	ns	

The leaf nutrient levels did not show significant differences among the treatments except Mg. Nitrogen, phosphorus and potassium levels were above the critical levels (N > 1.9%, P > 0.11 % and K > 1.2 %). But the leaf magnesium in control palms was below the critical levels (Mg > 0.25 %). Please see the Table 3.

Table 3. *Nutrient concentration in the 14th leaf*

Treatment levels	N%	P%	K%	Mg%
TSP	2.28	0.13	1.83	0.24
IRP	2.17	0.12	1.53	0.24
ERP	2.16	0.12	1.45	0.26
Control (No P source)	2.12	0.12	1.43	0.19
Level of significance	ns	ns	ns	*
LSD ($p \leq 0.05$)	-	-	-	0.023

N A Tennakoon, C P A Kurundukumbura, W Gunasena & K J S Perera

Experiment 6.0.3: Evaluation of the efficiency of rock phosphate as a phosphorus fertilizer for coconut growing soils in the Dry zone

The objective of this study was to test the solubility of various rock phosphates such as Imported Rock Phosphate (IRP), Eppawela Rock Phosphate(ERP) and High grade Eppawela Rock Phosphate (HERP) when applied to weakly acidic or neutral soils of the Dry zone.

Pot Experiment

A pot experiment was established to quantify the solubility of different phosphate sources applied to soils that were watered based on the rainfall pattern of the Dry zone. Four soils from the Dry zone and one soil from the Wet zone were taken for this experiment.

Details of soils used for the pot experiment are given below.

Great Soil Group	Soil series	Agro-ecological region	Soil sampling area
Regosols	Mampuri	DL_3	Madurankuliya
Latosols	Gambura	DL_3	Attavillu
Reddish Brown Earth	Elayapattuwa	DL_3	Kottukachchy
Red Yellow Podzolic	Boralu	WL_3	Walpita

Soils filled into pots (6 kg soil/pot) and treatments were applied as follows.

T_1 - No fertilizer
T_2 - TSP, 1.19 g/pot
T_3 - IRP, 1.83 g/pot
T_4 - ERP, 1.83 g/pot
T_5 - HERP, 1.37 g/pot

The phosphotic fertilizer rates based on general fertilizer recommendation for adult palms. According to that 600 g of ERP, 600 g of IRP, 474 g of HERP and 391 g of TSP are required for a coconut palm per year.

All the pots were treated with the basal doze of urea at the rate of 2.44 g, muriate of potash at the rate of 4.88 g and dolomite at the rate of 3.05 g per pot.

Available P contents in different soils in six sampling intervals i.e. two month intervals (mean values) are given in Table 4.

Table 4. *Mean value of 6 sampling intervals of P availability in the soils (mg/kg)*

Treatment	Boralu	Gambura	Mampuri	Elayapattuwa
T_1- TSP	13.3	13.8	21.3	29.0
T_2 - IRP	7.4	9.5	14.4	18.6
T_3 - ERP	5.3	8.8	13.0	17.5
T_4 - HERP	6.1	9.0	13.3	18.4
T_5 - Control	5.1	8.2	12.5	15.3
Significance	*	*	*	*
LSD ($P \leq 0.05$)	1.81	1.62	2.87	3.15

According to these results, the decreasing order of Available P in the different soil series is as follows.

Boralu soil (pH 5.58) - TSP > IRP > HERP > ERP > Control
Gambura soil (pH 5.89) - TSP > IRP > HERP > ERP > Control
Mampuri soil (pH 6.64) - TSP > IRP > HERP > ERP > Control
Elayapattu soil (pH 6.00) - TSP > IRP > HERP > ERP > Control

The available P concentration has shown a significant difference among the treatments particularly TSP and others. This clearly showed that IRP is better than either HERP or ERP to the coconut plantation in Dry zone. Available phosphorus content is higher in both Mampuri series and Elayapattuwa series soils than the Boralu and Gambura series soils.

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PROJECT 6.1: COMMON SALT AS A PARTIAL SUBSTITUTE FOR MURIATE OF POTASH FOR ADULT COCONUT PALMS

Experiment 6.1.1: Effect of sodium and chloride on yield of coconut (1996)

The experiment, on a Randomized Block Design with 3 replicates and 6 palms per plot, was established in 1996 at Wayagolla Estate, Attanagalla. The soil series of the site is Boralu series in WL_3. The site falls into land suitability class S_4.The age of the palms about 42 years.

The treatments of this experiment are

T_1 - Control (no potassium, sodium or chloride treatment)
T_2 - Muriate of potash (1.6 kg/palm/y)
T_3 - Potassium sulphate (1.8 kg/palm/y)
T_4 - Sodium chloride (1.2 kg/palm/y)
T_5 - Sodium sulphate (1.45 kg/palm/y)

All plots were given a basal dose of ammonium sulphate (1.2 kg/palm/y) and saphos phosphate (0.6 kg/palm/yr).

The nut yield of the site is given in Table 5. There was no significant differences in nut yield among the treatments up to 2004.

Table 5. *Nut yield of the experiments at Wayagolla site in 1997 – 2003 and 2004.*

Treatments	1997 – 2003 cumulative Nuts/palm	2004 Nuts (palm/year)
T_1 (No Fertilizer – Control)	382	51
T_2 (Muriate of potash)	459	66
T_3 (Potassium sulphate)	438	54
T_4 (Sodium chloride)	402	52
T_5 (Sodium sulphate)	456	59
Level of Significance	ns	ns

Evaluation of sodium chloride as a substitute for muriate of potash revealed that although the yield of potassium chloride treatment was higher than that of soidum chloride, the difference was not statistically significant. The yield difference between potassium chloride and sodium chloride treatments were 14 nuts/palm/year. It was further observed that yield differences were 15 nuts/palm/year and 1 nut/palm/year for the potassium chloride and control (no fertilizer) and sodium chloride and control (no fertilizer) respectively.

The nutrient contents of the leaf such as K, Na and Cl have shown significant differences ($p \leq 0.05$) among the treatments. Even though P has not shown any significant differences among the treatments, the p values are in the sufficiency range ($P > 0.11\%$)(Table 6).

Table 6. *Leaf nutrients in the 14th leaf*

Treatments	P %	K %	Ca %	Mg %	Na %	Cl %
T_1	0.154	0.88	0.48	0.26	0.18	0.75
T_2	0.143	1.23	0.40	0.15	0.14	0.86
T_3	0.156	1.10	0.45	0.20	0.16	0.64
T_4	0.146	1.52	0.33	0.25	0.36	0.52
T_5	0.143	0.67	0.37	0.18	0.35	0.57
Level of Significance	ns	$p \leq 0.01$	ns	ns	$p \leq 0.01$	$p \leq 0.01$
LSD (P<0.05)	-	0.37	-	-	0.11	0.12

N A Tennakoon, U S S Perera & F H A J R Silva

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

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

This experiment was established in 1991 with T x T seedlings planted on Andigama series soil at Ratmalagara Estate. The experiment was 3 x 3 x 3 N, K Mg factorial experiment. The treatment combinations are given in Table 7.

Table 7. *Treatment combinations and nut yield of the experiment*

Treatment levels	g/palm/y	Mean yield (nuts/palm/year)	
		2002 Dec - 2003 Oct	2003 Dec - 2004 Oct
N			
(Urea 46% N)			
N_1	0	36 ± 11	53 ± 9
N_2	600	38 ± 9	59 ± 7
N_3	1200	39 ± 8	60 ± 11
K			
(Muriate of potash 60% K_2O)			
K_1	0	34 ± 6	53 ± 7
K_2	1200	36 ± 10	58 ± 10
K_3	2400	43 ± 10	61 ± 10
Mg			
(Kieserite 24% MgO)			
Mg_1	0	36 ± 10	57 ± 11
Mg_2	750	37 ± 10	56 ± 10
Mg_3	1500	39 ± 10	58 ± 8
Level of Significance		LSD ≤ P 0.05	
N	*	4.635	
K	**	4.635	
N & Mg	*	8.002	

Basal phosphate application - Imported Rock Phosphate 600 g/palm/yr

Analysis found that only N & K were significant ($p \leq 0.05$) among the main treatments. Nitrogen and Mg two-way interaction also showed a significant ($p \leq 0.01$) difference in this year. The highest K levels applied palms have shown highest nut yield. The highest significant nut yield was obtained from the highest N, K & Mg levels applied palms.

Leaf sampling of the 14th leaf was done in March. The nutrients such as N, P, K and Mg have shown significant differences among the treatments (Table 8). The fertilizer application was done in April 2004.

Table 8. *Leaf nutrient levels in the 14th leaf*

Treatments	N	P	K	Mg
N (Urea 46% N)				
N_1	2.26	0.135	1.24	0.26
N_2	2.28	0.133	1.39	0.24
N_3	2.26	0.134	1.54	0.23
K (Muriate of potash 60% K_2O)				
K_1	2.26	0.132	1.44	0.23
K_2	2.29	0.134	1.41	0.24
K_3	2.25	0.136	1.32	0.25
Mg (Kieserite 24% MgO)				
Mg_1	2.34	0.136	1.50	0.26
Mg_2	2.62	0.140	1.41	0.24
Mg_3	2.74	0.125	1.26	0.24
Level of Significance	*	***	**	*
LSD ($p \leq 0.05$)	0.089	0.006	0.129	0.02

This has shown further that N, P, K and Mg have shown higher values in magnesium treated palms. In addition to that K levels and Mg levels are high in N treated palms also.

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Experiment 7.0.2: Dissolution of dolomite in high pH soils (2004)

A POT EXPERIMENT

The objective of this experiment was to study the dissolution of dolomite in high pH soils and to study the soil pH variation in high pH soils due to ammonium sulphate/urea/dolomite application. Five soil series of the Dry zone were used for this experiment. A pot was filled with 5 kg of soil and fertilizer applied as indicated. Pots were watered according to the rainfall pattern existing in the location of the soil sampling.

T_1 - Control (no dolomite, urea and $(NH_4)_2SO_4$)
T_2 - Dolomite only (2.5 g dolomite/5 kg soil)
T_3 - Ammonium sulphate only (4.38 $(NH_4)_2SO_4$/5 kg soil)
T_4 - Urea only (2.0 g urea/5 kg soil)
T_5 - Dolomite + urea (2.5 g dolomite + 2 g urea/5 kg soil)
T_6 - Dolomite + Ammonium sulphate (2.5 g dolomite + 4.38 $(NH_4)_2SO_4$/5 kg soil)

The experiment (90 pots) was established as a Randomized Complete Block Design with 3 replicates for each soil at the green house in Bandirippuwa Estate in December, 2004. Soil sampling has to be done in 14 days, 1 month, 2 months and the 2 months interval upto a year.

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 lands of 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.

This experiment, on a Randomized Block Design with 3 replicates and six palms per plot, was commenced 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 the all sites are given in Table 9.

Table 9. *Treatment combinations in 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	1050/1570	2800	1750
T_5	1700	1225/1905	3400	2125

The nut yield of the experiment are given in Table 10.

Table 10. *The nut yield of Mangala-eliya site*

Treatment	Cumulative nut yield 2001-2003	Nut yield (palm/year) 2004
T_1	206	79
T_2	260	93
T_3	245	96
T_4	249	106
T_5	240	98
Level of Significance	$P \leq 0.05$	$P \leq 0.01$
LSD ($P \leq 0.050$)	14	12

There was significant nut yield increase (34%) from the palms receiving 1400 g urea, 1050 g Imported Rock Phosphate, 2800 g Muriate of Potash and 1750 g Dolomite (T_4) over control (no fertilizer) and 15% nut yield increase was observed in the recommended fertilizer treated palms (T_2) over the control.

Fourteen percent nut yield increase was observed in the palms receiving higher doses (T_4) compared to palm receiving normal recommended fertilizer (T_2). This year i.e. four years after fertilizer application, this nut yield increase was shown particularly on Borupan soil series in the Dry zone where the site is located. Increase of urea by 600 g, Imported Rock Phosphate by 450 g, Muriate of potash by 1200 g and Dolomite by 750 g (T_4) have shown the highest nut yield compared to the recommended dose (T_2).

Leaf nutrients did not show any significant differences among the treatments (Table 11).

Table 11 : *Leaf nutrient levels of the 14th leaf*

Treatments	N%	P%	K%	Mg%
T_1	2.09	0.135	1.06	0.35
T_2	2.07	0.137	1.17	0.32
T_3	2.07	0.137	1.18	0.31
T_4	2.10	0.132	1.19	0.30
T_5	2.11	0.135	1.20	0.30
Level of Significance	ns	ns	ns	ns
LSD ($p \leq 0.05$)	-	-	-	-

All the leaf nutrients were in the sufficiency range (N ≥ 1.9%, P ≥ 0.11%, Mg ≥ 0.25%) except K levels in few treatments (K ≥ 1.2%).

Experiment 7.1.2.2: Naiwala

The leaf samples collected in October were analyzed for nutrient status of the experiment. Only potassium level has shown significant differences in this year (Table 12). The 2nd different treatment combinations were applied in September. The nut yield as well as female flowers have not shown significant differences in this year too (Table 13).

Table 12. *Leaf nutrient of the 14th leaf*

Treatment	N %	P %	K %	Mg %
T_1	2.10	0.143	0.65	0.22
T_2	2.16	0.146	0.93	0.17
T_3	2.10	0.139	0.83	0.17
T_4	2.18	0.142	0.83	0.17
T_5	2.25	0.143	1.06	0.15
Level of significant	ns	ns	**	ns
LSD ($p \leq 0.05$)	-	-	0.1775	-

Table 13. *Nut yield and female flowers of the Marapola site*

Treatment	Nut yield ha/year (2003 October - 2004 October)	Female flowers ha/year (2003 October - 2004 October)
T_1	632	20362
T_2	1068	19363
T_3	831	18590
T_4	931	18833
T_5	859	16824
Level of significant	ns	ns
LSD ($p \leq 0.05$)	-	-

Experiment 7.1.2.3: Kobeigane

The 1st leaf samples after the 1st fertilizer application were taken in September and 2nd different treatment combinations were applied in October 2004. Leaf nutrients have not shown significant differences in this year (Table 14). The nut yield has also not shown significant difference in this year. But the female flowers of the palms have shown significant increase from the palms receiving 1400 g Urea, 1570 g Eppawela Rock Phosphate, 2800 g Muriate of Potash and 1750 g Dolomite (T_4) than other treatments (Table 15). There is also no significant difference among the treatments in percentage setting of nuts.

Table 14. *Leaf nutrient of the 14th leaf*

Treatment	N %	P %	K %	Mg %
T_1	1.95	0.126	0.79	0.30
T_2	1.96	0.136	0.92	0.31
T_3	1.99	0.141	0.90	031
T_4	2.15	0.143	0.94	0.33
T_5	2.06	0.147	0.94	0.33
Level of significant	ns	ns	ns	ns
LSD (p 0.05)	-	-	-	-

Table 15. *Nut yield and female flowers of the Kobeigane experimental site*

Treatment	Nut yield palm/year (2003 October - 2004 October)	Female flowers palm/year (2003 October - 2004 October)
T_1	70	146
T_2	72	160
T_3	76	173
T_4	82	188
T_5	78	177
Level of significant	ns	*
LSD (p 0.05)	-	23.64

Experiment 7.1.2.4: Sirigampola

The leaf sampling collected in September were analyzed and only potassium nutrient has shown significant difference in this year (Table 16).

Table 16. *Nutrient level of the 14th leaf at Sirigampola site*

Treatment	N %	P %	K %	Mg %
T_1	2.05	0.13	0.72	0.29
T_2	2.05	0.14	0.93	0.32
T_3	2.13	0.14	1.02	0.32
T_4	2.14	0.14	1.10	0.31
T_5	2.19	0.14	1.09	0.33
Level of significant	ns	ns	*	ns
LSD (p 0.05)	-	-	0.2208	-

Fertilizer application was carried out in December 2004.

The nut yield and female flower production have not shown significant difference in this year (Table 17).

Table 17. *Nut yield and female flowers of the experiment*

Treatment	Nut yield palm/year (2003 October - 2004 October)	Female flowers palm/year (2003 October - 2004 October)
T_1	72	197
T_2	75	223
T_3	74	238
T_4	74	238
T_5	81	309
Level of significant	ns	ns
LSD ($p \leq 0.05$)	-	-

Experiment 7.1.2.5: Wellawa

The 1st fertilizer application was carried out in December. The nut yield has not shown significant difference among the treatment in this year (Table 18).

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

Experiment 7.2.1: Determination of critical levels for Zn and Cu in the coconut palm (1997)

This experiment, in a Randomized Block Design with 3 replicates and 6 palms (40 years old) per plot was established in 1997 at the following two locations. The age of the palms was about 40 years at both sites.

Expt.No	Location	Agro-ecological Region	Soil type	Land suitability class
7.2.1.1	Pottukulama Research Station	IL_3	Deep sandy loam (Welipelessa series)	S_2
7.2.1.2	Ratmalagara Research Station	IL_1	Sandy clay loam with gravel in the Sub soil (Andigama series)	S_4

The treatment combination of $ZnSO_4.7H_2O$ and $CuSO_4.5H_2O$ and the Zn and Cu levels of soils in both sites are presented in Table 18. The basal doses for all treatment palms were 3 kg of APM and 1 kg of dolomite per palm.

The leaf content of Zn and Cu is also not different according to the different levels of Zn and Cu application. Therefore this experiment at both sites was terminated at the end of year 2002. But this experiment was maintained without application of treatments and leaf and soil samples were collected in 2003 and 2004 to see the situation of different levels of Zn and Cu application to the soils. Soils concentrations of Zn and Cu at both sites are given in Table 18.

Table 18. Treatments and Zn and Cu concentrations of the soils at RE and PRS sites

Treatment			RE site				PRS site			
	$CuSO_4$ g/palm	$ZnSO_4$ g/palm	Zn mg/kg		Cu mg/kg		Zn mg/kg		Cu mg/kg	
			0-9 cm	9-18 cm	0-9 cm	9-18 cm	0-9 cm	9-18 cm	0-9 cm	9-18 cm
T_1	-	-	3.02	2.81	2.56	2.23	3.76	3.31	0.79	0.54
T_2	50	100	16.54	5.50	13.53	3.79	40.33	5.01	6.92	1.88
T_3	50	200	15.90	3.17	11.13	4.13	52.32	7.00	14.90	2.79
T_4	100	200	51.77	14.85	20.44	5.61	26.19	3.76	16.08	8.05
T_5	100	200	38.70	12.68	33.30	8.63	60.63	19.22	34.50	7.12
T_6	200	400	140.65	11.07	104.26	9.27	120.80	29.80	117.30	33.82
Level of significant	Treatment		***		***		***		***	
	Depth		***		***		***		***	
LSD ($p \leq 0.05$)	Treatment		10.78		7.19		22.32		8.59	
	Depth		6.22		4.15		12.88		4.96	

The leaf nutrient levels are given in Table 19.

Table 19. *Leaf nutrient levels*

Treatments			RE site		PRS site	
	$CuSO_4$ g/palm	$ZnSO_4$ g/palm	Zn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
T_1	-	-	30	10	32	8
T_2	50	100	32	10	36	10
T_3	50	200	39	11	34	9
T_4	100	200	40	11	38	9
T_5	100	200	33	10	41	8
T_6	200	400	38	11	39	10
Level of significance			-	-	-	-
LSD ($p \leq 0.05$)			-	-	-	-

Zinc and Cu concentration of the leaf were in the sufficiency range and the application of heavy doses of micronutrients such as Zn and Cu, were not taken up accordingly by the plans.

The soil analytical results clearly showed that the Zn and Cu concentrations of the soils were higher according to the increase in Zn and Cu levels. This means that the applied Zn and Cu concentrations are still bound with the soil particles even 2 to 3 years after the experiment was terminated. Thus soil application of micro nutrients as fertilizers did not lead to uptake by coconut palms.

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

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

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

The experiment on land suitability class S_4 was commenced in 2000 in a field containing Boralu series soil in Bandirippuwa Estate. Ten T x T palms, which were 20 years old, were randomly selected as replicates for further experiments. The number and the weight of each component harvested and removed from the palm was determined monthly.

The collection of different components of the coconut palms caused difficulties as it was difficult to keep certain components like spathes in the site as these materials were being removed from the site by residents for their day today necessities.

Therefore a new site at BE was selected in 2004 with proper covering. The palm components will be collected from 2005.

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

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

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

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

During the year 2004, the activities of the experiment were not commenced due to shortage of staff members of the Division. The activities of the experiment will be commenced in 2005 as scheduled.

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

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

This experiment, on a Randomized Block Design with 3 replicates and 6 palms (15 years old) per plot, was established in 1996 at Ratmalagara (IL_1). It was located on a shallow sandy clay loam soil (Andigama series) falling to land suitability class S_5. A sub-terrain tubing system and screw drippers were established to provide water to coconut palms at different irrigation intervals.

The treatments were given in Table 20.

Table 20. *Treatments effect from November 2002*

Treatment	Irrigation intervals in days	Application of water per day/palm in liters	Application of water per day/palm in hours	Rate of application of fertilizer	No. of time of fertilizer application per year
T_1	-	-	-	3 kg	1
T_2	6	40	2	3 kg	1
T_3	3	80	2	3 kg	1
T_4	6	40	2	250 g	12
T_5	3	80	2	250 g	12

Table 21. *Nut yield of the experiment*

Treatment	Nut yield per palm per year	
	October 2002 to October 2003	October 2003 to October 2004
T_1	48	74
T_2	64	78
T_3	53	85
T_4	82	98
T_5	65	84
Level of Significance	ns	ns

Nut yield did not show significant differences among the treatment in this year (Table 21). However this irrigation experiment showed 32% yield increase compared to control (no irrigation). This increase was observed 40 l/palm/day at 6 days interval with 250 g of APM-W plus 83 g of dolomite (T_4) at monthly interval per year. The yield of this treatment (T_4) was 26% higher than application of 40 l/palm/day at the same interval but with application of 3 kg of APM-W and 1 kg of dolomite annually (T_2). The results further showed that 12 split application of APM-W and dolomite with irrigation (fertigation) is more beneficial than irrigation alone.

The leaf sampling carried out in August was analyzed and significant differences of treatments were not observed (Table 22).

Table 22. *Nutrient levels of 14th leaf*

Treatment	N %	P %	K %	Mg %
T_1	2.24	0.119	1.44	0.25
T_2	2.23	0.125	1.52	0.24
T_3	2.30	0.124	1.53	0.23
T_4	2.27	0.128	1.55	0.23
T_5	2.95	0.125	1.42	0.24
Level of significant	ns	ns	ns	ns
LSD ($p \leq 0.05$)	-	-	-	-

Leaf nutrient levels did not show significant difference this year.

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Experiment 10.0.2: Evaluating the effect of fertigation in coconut

This experiment was established in 2004 at Ratmalagara Estate(IL_1). It was located on a shallow sandy clay loam soil (Andigama series) falling into land suitability class S_5. This experiment was Randomized Complete Block Design with 3 replicates and 6 palms (15 years also) per plot. Treatment combinations were given in Table 23.

Table 23. *Treatment combinations of the experiment*

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)

The demarcation of the plot and lay out of the irrigation system was completed during this year.

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PROJECT 27: STUDIES ON CHEMCIAL AND MINERALOGICAL PROPERTIES F 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 soil for coconut. Soil samples were collected to represent the top layer (0-25 cm depth) and the sub layer (25-50 cm) of two major soil series, namely Boralu series and Pallama 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 (14^{th} frond) from coconut palms were also taken from the same location.

The soil series Kuliyapitiya, Kurunegala, Boralu and Pallama were sampled and analyzed for soil and leaf nutrient levels. The results were published in the past Annual Reports.

It was planned to sample from Wariyapola (50,053 ha) and Maho (16,355 ha) soil series. But due to financial crisis, this sampling was not carried out in this year. The sampling will be taken in the next year.

N A Tennakoon, D M D I Wijebandara & A H N Hewage

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

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

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

A new site was selected at Bandirippuwa Estate in the year 2003. The experiment was established as demonstration block having 9 palms (25 years old) in each treatment. Treatments were applied in May.

The annual treatment application was as follows.

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 + 250 kg MOP per palm
T_6 - 30 kg Gliricidia + 750 g SP + 1500 g MOP + 1000 g dolomite per palm

Gliricidia was not applied at BE site.

Leaf samples collected at Ratmalagara Estate site on May 2004 was analyzed and results are given in Table 24. Leaf nutrient K has shown significant difference ($p \leq 0.05$) among the treatments. This difference was clearly shown between fertilized palms and no fertilized palms. All 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 24. *Leaf nutrient levels in 14th leaf*

Treatment	N %	P %	K %	Mg %
T_1	1.91	0.122	0.81	0.32
T_2	2.06	00124	1.20	0.26
T_3	1.96	0.125	1.24	0.26
T_4	2.06	0.127	1.26	0.28
T_5	1.98	0.136	1.29	0.28
T_6	2.05	0.127	1.29	0.25
Level of significant	ns	ns	*	ns
LSD ($p \leq 0.05$)	-	-	0.299	-

The yield data of April 2003 to March 2004 and the cumulative yield data from April 1997 to March 2003 are given in Table 25.

Table 25. *Nut yield data in the Ratmalagara Experimental Site*

Treatment	April 1997 to March 2003 Nuts/palm	April 2003 to March 2004 Nuts/palm/yr
T_1	319	51
T_2	384	59
T_3	414	64
T_4	411	61
T_5	444	69
T_6	381	60
Level of Significance	* only in year 2002/2003	ns
LSD ($p \leq 0.05$)	20	-

Nut yield of the palm receiving poultry manure was increased by 35% compared to that of the control (no fertilizer) while the yield increase by inorganic fertilizer over the control (no fertilizer) was 16%. But this difference was not shown significantly. Among other organic sources such as cattle manure, goat manure and gliricidia, the yield increase was 26%, 20% and 18% over the control (no fertilizer) respectively. Seventeen 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, goat manure etc were more economical and beneficial than that of inorganic fertilizer.

The nut yield and female flowers of the Bandirippuwa Experimental site have not shown significant difference in this year (Table 26).

Table 26. *Nut yield of the experiment at BE site*

Treatment	Nut yield per palm/year 2003 May to 2004 May	Female Flowers 2003 May
T_1	97	92
T_2	101	83
T_3	93	80
T_4	85	88
T_5	116	96
T_6	81	82
Level of Significance	ns	ns

N A Tennakoon, S D H Bandara, W Gunasena & M H Danasena

Hydro geological study on deep ground water aquifers in the coconut growing area of Puttalam and Kurunegala Districts (Cess Project)

1) Puttalam Disrict

This project in Puttalam District was completed in 2002 and details were given in past annual reports. Detailed map is attached and maps are available at the Coconut Research Institute for use by growers (Figure 1).

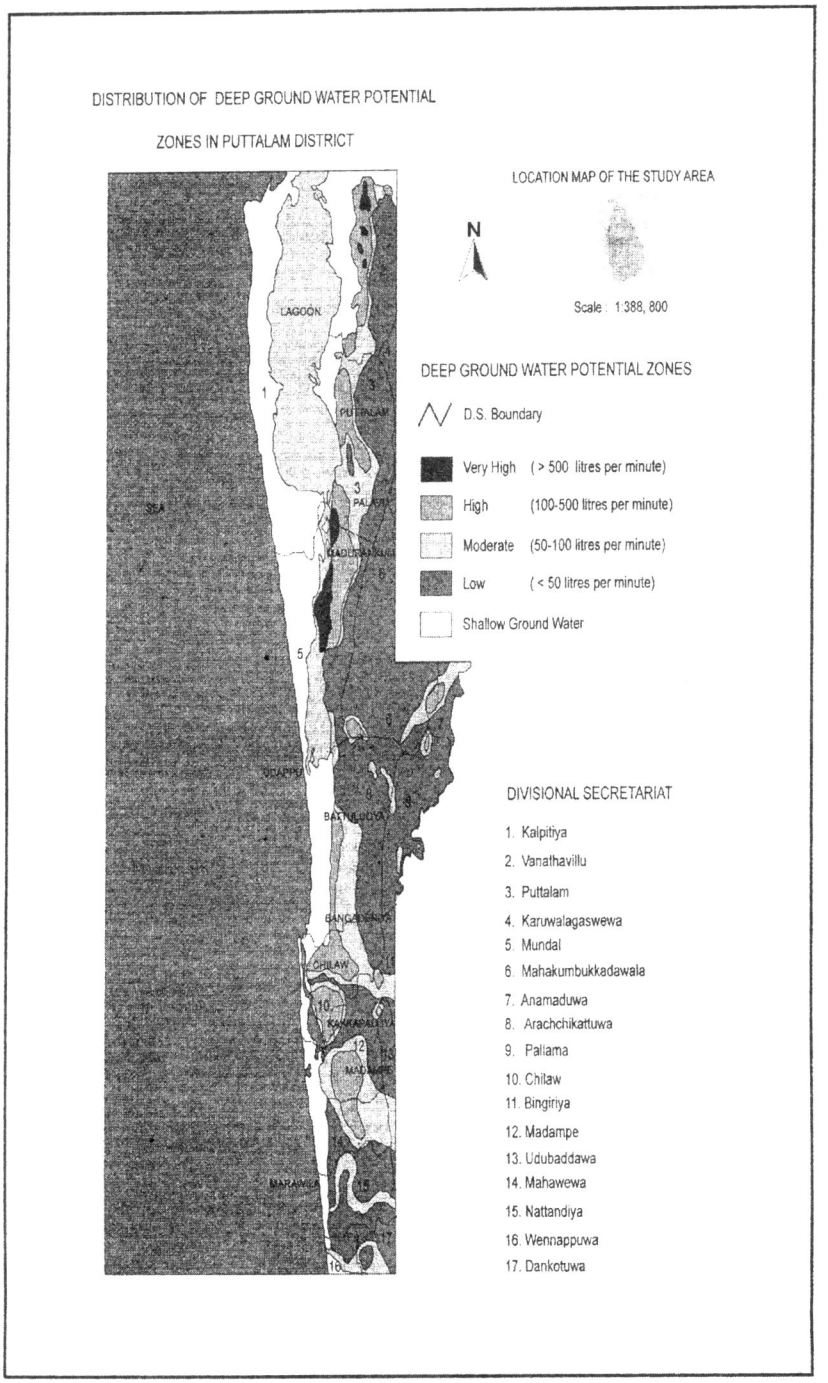

Figure 1 : *Distribution of deep ground water potential zones in Puttalam District*

2) Kurunegala District

For the determination of ground water availability in Kurunegala District, 4 one inch topographical sheets such as Dandagamuwa, Kurunegala, Nalanda and Wariyapola were used. The ground water availability in hard rock areas is very complex rather than the groundwater availability in sedimentary rock areas (i.e. Puttalam District).

The ground water potential in the Kurunegala District is categorized into five major groups (Figure 2). Please see the Table 27 for details.

Table 27. *Details of the water zones in Kurunegala District*

Flow rate of aquifer (l/minute)	Potential	Extent (ha)	Expected depth of well (m)
more than 200	Very high	< 9400	40-50
200 - 100	High	16680	50-60
100 - 50	Moderate	18560	60-65
50 - 10	Low	3720	60-70
< 10	Very Low	1920	70 <

The extent of each topographical sheets in details are given in Table 28.

Table 28. *Extent (ha) in details*

	Extent					
Flowrate of aquifer (l/minute)	Wariyapola	Dandagamuwa	Kurunegala	Nalanda	Gampaha	Total
> 200	18480	38680	2160	-	80	59400
200 - 100	3560	11080	2040	-	-	16680
100 - 50	680	6920	10120	840	-	18560
50 - 10	-	1360	480	1880	-	3720
< 10	1880	-	-	40	-	1920
Total	24600	58040	14800	2760	80	100280

The location of each topographical sheets in details are given in Table 29.

Table 29. *Locations in details*

	Locations				
Flow rate of aquifer (l/minute)	Wariyapola	Dandagamuwa	Kurunegala	Nalanda	Gampaha
> 200	Alluvial, granite & granatic gneiss	Charnockite & alluvial	Charnockite	-	Undifferentiated gneiss
200 - 100	Biotite gneiss & hornblende & alluvial	Charnockite	Granite & Granatic gneiss	-	-
	Location				
Flow rate of aquifer (l/minute)	Wariyapola	Dandagamuwa	Kurunegala	Nalanda	Gampaha
100 - 50	-	Quatzite	Charnockite	Granite & Granatic gneiss	-
50 - 10	Biotite gneiss & hornblende & alluvial	Charnockite	Undifferentiated gneiss	Charnockite	-
< 10	Biotite gneiss & hornblende & alluvial	-	-	Charnockite	-

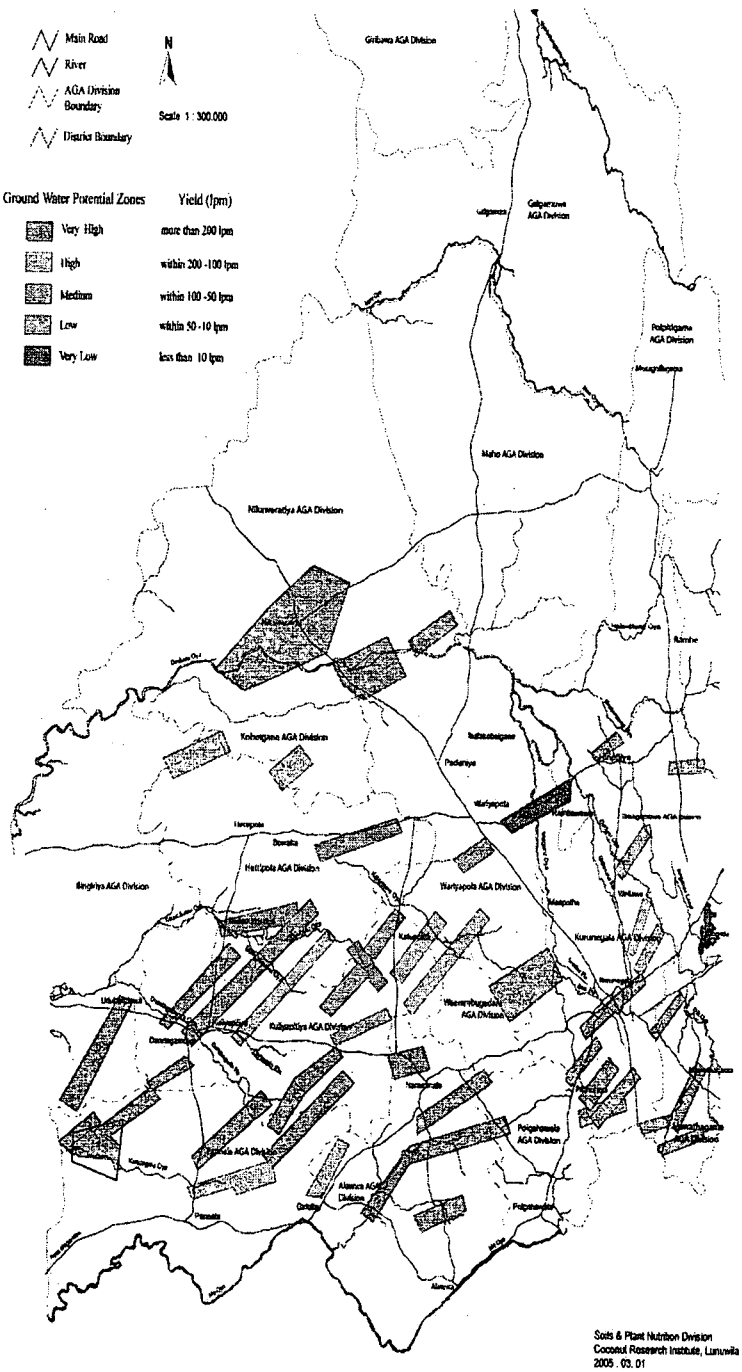

Fig 2: *Distribution of deep ground water potential zones in Kurunegala District*

Demonstrations for Irrigation/ Fertigation

a) Using Drippers

This was established in Bandirippuwa Estate. Forty two adult coconut palms and 16 young coconut palms were included for this demonstration. Four drippers for adult coconut palms and 2 drippers for young coconut palms were set in the manure circle of coconut palms. The water was supplied to adult coconut palm and a young coconut palms as 40 l and 10 l per palm/day respectively and the application frequency was at 2 days interval.

Urea 100 g per month/palm (@ 1200 g/yr) and Mriate of Potash 200 g/month/palm (@ 2400 g/yr) were sent through water. Eppawela Rock Phosphate 300 g/wetting point/3 m (@ 1200 g/yr) and Dolomite 375 g/wetting point/3 m (@ 1500 g/yr) were applied to the soil.

b) Using Soaker Hose

This demonstration site was also established in Bandirippuwa Estate. Water was supplied as following treatments.

T_1 - 8 feet long soaker hose - full circle - surface application
T_2 - 4 into 1 foot soaker hose connected with conduit tube - full circle, surface application
T_3 - 8 feet long soaker hose - full circle, subsurface application

Twenty coconut palms were included in each treatments.

N A Tennakoon, D P Panditaratne, K R E M Fernando & E A Chandradasa

3. SERVICE FUNCTIONS

Differential Fertilizer Recommendation	-	95 growers (4200 ac)
Land suitability tests for coconut cultivation/surveys	-	23 growers
Inorganic fertilizer analysis	-	128 samples
Organic fertilizer analysis	-	54 samples
Analysis of coir pith samples	-	503 samples
Soil analysis	-	1223 samples
Leaf analysis	-	2405 samples
Water analysis	-	16 samples
Participation in training programmes	-	01

4. EXTENSION ACTIVITIES - SOIL

Dr. N.A. Tennakoon participated as a resource person in 3 programmes on Usage of Eppawela Rock Phosphate for coconut held in Gampaha, Kurunegala & Wennappuwa organized by Phosphate Lanka Pvt. Ltd., Colombo.

Dr. N.A. Tennakoon participated as a resource person in training programme conducted by Coconut Development Training Centre and NIPM.

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

The research on coconut mite received the highest priority of the Division. The research on the development of an integrated management programme for coconut mite mainly focused on biological and chemical control methods. Application of a 30% mixture of used engine oil at 2-monthly intervals was recommended to manage the pest particularly, in new areas of infestations and in home gardens.

A method for laboratory rearing of the predatory mite, *Neoseiulus baraki* was developed. *N. baraki* could be mass bred using the flour mite, *Tyrophagus putriscentiae* on laboratory arenas. In experimental areas without a water barrier, a single female predatory mite produced 24 mites in 3 weeks. In the mass breeding culture of the insectry a single female produced about 15 mites in 3 weeks. The maximum average fecundity of 25 eggs was obtained at 25°C. Mass breeding of *N. baraki* for field studies commenced. It was determined that coconut mite and *N. baraki* could be bred on 3-5 month old embryo-culture seedlings. A 265-fold increase in coconut mite numbers in 5 weeks and 16-fold increase in *N. baraki* numbers in 2 weeks was obtained on embryo-culture seedlings. An exotic predatory mite of coconut mite *Proctolalaeps bickleyii* was imported from Brazil to determine its suitability as a prospective candidate for biological control of coconut mite.

The collaborative project with CABI Bioscience, U.K. funded by the Department for International Development, U.K. to develop an integrated management programme for coconut mite with emphasis on the use of entomopathogenic fungus *Hirsutella thompsonii* was continued. A survey conducted in different Districts indicated that *H. thompsonii* was present in all the areas with low and varying incidence. The highest percentage of nuts with the fungus was obtained from Kurunegala District which was 7.6%. Studies revealed that *H. thompsonii* was not infectious to the predatory mite, *N. baraki*. Field studies were initiated to investigate the effectiveness and persistence of four local isolates of the fungus.

A pilot trial to confirm the efficacy of carbosulfan 20% (Marshal SC 20) by root feeding and crown spraying did not reveal a considerable reduction in coconut mite population and reduction in damage symptoms over time. Preliminary field trials conducted to determine the efficacy of soybean oil, fenazaquin and sparrow oil against coconut mite did not give promising results.

Studies on migration of coconut mite proved that mites disseminate by wind. A survey was conducted in different areas of coconut mite infestation to determine the crop loss at harvest. It was found that the highest incidence of damaged nuts (94.4%) was found in Anuradhapura area while the lowest was recorded from Kurunegala area (69.8%0). The crop loss at harvest was highest in the Puttalam District and lowest in Rajangane area. The study on mite damage and palm nutrition did not show any relationship between severity of damage and nutrition level of the palms or a significant difference in the nutrient levels between different levels of nutrition.

A trial conducted to evaluate drenching of the fungicides, "contaf", bavistin and "folicur" in managing leaf rot disease in the field indicated that none of the fungicides completely control the disease but folicur and contaf gave considerable control.

The study to understand the population fluctuation pattern of the parasitic nematode, *Radopholus similis* infesting coconut roots was completed. Studies to determine the effect of introducing cell sap of LSD-affected and healthy palms by using test plants, maize and embryo-culture coconut seedlings were not conclusive.

The Division continued to serve the coconut growers during the year. Advice on management of pests and diseases was given while field inspections were made in instances where specialized advice was required. Many infestations of coconut caterpillar were reported from several areas and

they were successfully managed by releasing nearly 820,750 laboratory-bred parasitoids. A total of 3093 pheromone vials were sold and 32.1 l of monocrotophos was issued to the growers to manage red weevil.

2. RESEARCH PROJECTS

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

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

A new study was initiated to determine the population fluctuation patterns of coconut mite and predators and assessment of damage on immature nuts in Kalpitiya and Madurankuliya areas (Puttalam District), Madampe area (Kurunegala District) and Rajangane area (Anuradhapura District). In each area 3 coconut mite infested sites were sampled and from each site a single nut from each of 5 palms were assessed in every 3 month interval. Furthermore, in 2 sites of each area 30 palms were selected and the total number of nuts and the number of damaged nuts in the 4th bunch was recorded. The study is in progress.

L. C. P. Fernando, K. A. S. Chandrasiri, K. F. G. Perera, P. H. A. R. de Silva & D. C. L. Hapuarachchi

Experiment 27.31: Determination of peak time of migration (2003)

Previous laboratory and field studies indicated that coconut mites leave the perianth early in the morning reaching a peak at 4.00 a.m. This was confirmed in the field by repeating the same study in two more locations i.e at Maduru Oya and Vanathavillu. Nut samples from the 4th bunch were collected at 2h intervals from 6 pm to 10.00 a.m. The mites on the surface were counted under the microscope and the total population of each nut was assessed. Results showed that the percentage of mites leaving the perianth reached its peak around 4.00 am confirming the previous findings.

I.R. Wickramananda, A.D.N.T. Kumara S.R. Sarathchandra, D. Appuhamy & N.G. Premasiri

Experiment 27.59: Determination of modes of migration (2004)

Wind, phoretic insects, rainwater and negative geotrophic walking have been suggested as the main modes of migration for eriophoid mites. An experiment was designed to trap the coconut mites carried by the wind. Traps made of transparency sheets coated with a thin layer of Vaseline were hung at the level of canopy of affected fields at different heights and distances from the canopy. Mites were trapped and it was clear that mites are carried mainly by the wind.

I.R. Wickramananda, A.D.N.T. Kumara S.R. Sarathchandra, D. Appuhamy T. Bandara & N.G. Premasiri

Experiment 27.32: Estimation of crop loss due to coconut mite damage (2002)

The survey was conducted in Puttalam, Anuradhapura, Rajangane, Polonnaruwa and Kurunegala areas where the mite infestation was prevalent. In the survey, harvested heaps were randomly selected in 8-15 locations per each area and the survey was carried out monthly in each area. A minimum of 100 nuts or 1% of the total heap (which ever is higher) was sampled for the survey. The nuts were first categorized into two groups according to the size [Normal size (S1) and smaller size (S2)]. Then within each size category nuts were grouped into four categories - mite free nuts, normal size nuts with surface damage, deformed nuts and empty nuts.

Results showed that among the affected areas, Anuradhapura had the highest incidence of mite damage as measured by the percentage of damaged nuts. Kurunegala, still being a new area had the

lowest incidence. It was interesting to note that Puttalam area where the mite was first recorded had a lower incidence of damaged nuts than Anuradhapura and Polonnaruwa (Table 1). This could probably be due to the reduction of damage over time due to several factors such as building up of predators and imposed control measures.

Table 1. *Coconut mite incidence in different areas*

Infested zone	Percentage of nuts	
	damaged	undamaged
Anuradhapura	94.4	5.5
Polonnaruwa	94.5	5.5
Rajangane	90.5	9.5
Puttalam	81.1	18.9
Kurunegala	69.8	30.2

Table 2 shows that percentage of damaged nuts is high in the small sized nuts. Whether the damaged nuts are more prone to mite attack or the affected nuts becomes smaller in size is not clear. Similarly, deformed nut have a higher incidence of mite than normal nuts.

Table 2. *Incidence of mite damage in two different size categories and different shapes*

Nut shape	Nut size	
	Large	Small
Normal	74.3	86.8
Deformed	98.7	99.7
Barren	73.7	83.6

The percentage nut loss as measured by the change in size and shape in different districts is given in Fig. 1. According to the figure it was clear that Puttalam district where the mite is widespread had the highest nut loss. Rajangane had the lowest loss. This could be mainly due to the large size of the nuts which is inherent to that area.

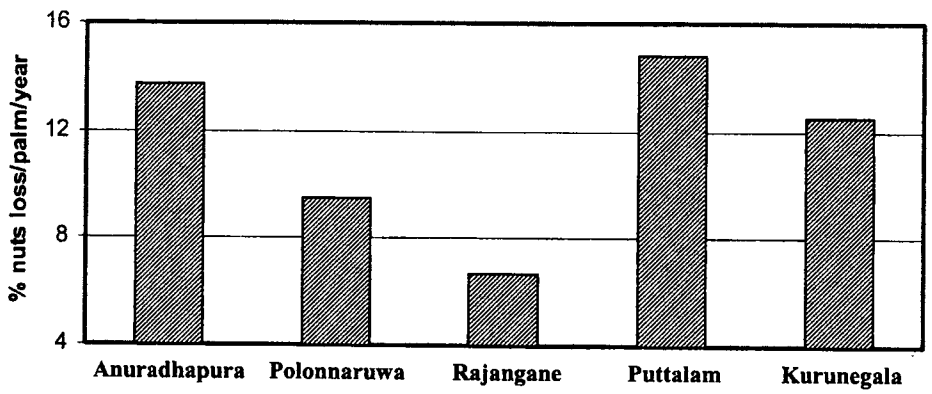

Fig. 1. *Percentage nut loss in harvested heaps in different areas*

I.R. Wickramananda, T.S.G. Peiris (Biometry), N. Fernando(Agronomy) & T. Bandara

Experiment 27. 59 : Assessment of immature nut fall due to mite damage (2004)

This study was conducted to determine the effect of mite damage on the immature nut fall. Two groups of palms with and without (or very low) mite damage were selected. The palms with no or low mite damage were treated with 30 % used engine oil mixture to maintain the palms free of mite attack. Weekly observations were made to count immature nuts fallen. The fallen nuts were categorized into three groups, i.e. mite free, initial symptoms, brown symptoms and cracked at the inner perianth (y shape crack). The study is being continued to see whether there is any difference in the immature nut fall between the infested and uninfested palms.

Results so far showed that irrespective of the damage level of the palm, about 70% of the nuts fallen are free from mite damage and caused probably by physiological reasons, moisture stress or other factors. Thirty percent of the nuts fallen were infested nuts in both treated and untreated palms. There was a difference between the fallen nuts having the initial symptoms between the treated and untreated palms but not in any other categories (Table 3). Collection of nut fall data is being continued in two locations to verify the results so far obtained in order to come to some conclusion.

Table 3. *Different categories of fallen nuts in infested and control palms*

Category	Mite free	Initial	Brown	Cracked	Infested
Treated	71.85482	9.311651	1.202941	17.59857	28.14518
Untreated	69.13661	15.42605	1.926216	13.49984	30.86339

I.R.Wickramananda, , T. Bandara & N. Fernando

Experiment 27.33 Studies on the effect of nutrition level of coconut palms on the coconut mite damage (2002)

The study was conducted in a field where a trial to determine the optimum fertilizer mixture is being conducted. Palms that have been fertilized at the following levels were used for the experiment. T1- No fertilizer, T2- Recommended dosage of NPK (Adult Palm Mixture: Urea 800 g; Phosphate 600 g; Muriate of Potash 1600; Dolomite 1000 g) and T3- Double dosage. Three palms from each block were selected and leaf samples were collected from the 14th frond. Nutrient levels of the samples were analysed and the yield data was recorded. In the previous year it was found that the levels of major and some micronutrients were not significantly different between the three treatments. However the yield data were recorded considering the severity of mite damage for 6 picks and the symptoms initiation was recorded twice in the fourth bunch at two months intervals to see if there is a difference.

As shown in the Table 4 a significant difference was not observed in the yield with respect to the different damage categories between treatments. And there was no clear relationship between the nutritional status and the initiation of symptoms in the fourth bunch (Table 5).

Table 4. *Mean yield in different treatments for one year*

Treatment	No Mite	Surface damaged	Deformed/Small	Rejected	Total
Control	1.92	6.29	1.43	0.72	10.36
APM	2.49	7.18	1.21	0.47	11.34
Double APM	2.80	5.43	1.52	0.55	10.3
Significance	NS	NS	NS	NS	NS

Table 5. *Damage assessment in the 4th bunch (Percentage damaged nuts in the fourth bunch)*

Treatment	1	2
Control	27.46392	59.18562
APM	29.01124	59.15796
Double APM	40.11267	53.8207

I.R.Wickramananda, , T. Bandara & R.Wijetunga & N. Fernando

Experiment 27.39 Studies on breeding of coconut mite and predatory mite on embryo-culture seedlings (2003)

An experiment was conducted to quantify the number of coconut mites and predatory mites that could be bred on embryo culture seedlings of different ages. Embryo-culture coconut seedlings in three different stages viz. 0-2 months, 2-4 months and 4-6 months old were obtained from the Tissue Culture Division and used for the experiment. Thirty seedlings from each age group were used for the experiment. Seventy five coconut mites were introduced to each seedling and the infested seedlings were kept at a temperature of 27^{0}C and 70-80% RH. From seedlings of each age group 6 randomly selected seedlings were dissected at 2, 3, 4, 5 and 6 weeks after the introduction of mites and the total number of mites recorded. Coconut mite bred on all ages of seedlings. The highest numbers of mites were obtained from 4-6 month old seedlings at 5 weeks after introduction (Table 6).

Table 6. *Mean number of coconut mites bred on seedlings of different ages at different intervals after introduction*

Age of seedlings	Mean number of mites ±S.E. per seedling after different intervals (weeks)				
	2	3	4	5	6
0-2 months	515±81.0	807± 132.7	3604± 655.6	4473± 624.4	1956± 253.4
2-4 months	260±54.5	671±135.0	2996±680.9	8842±1332.5	5302±1148.9
4-6 months	215±41.4	1141±91.3	4404±221.7	20099±3465.6	10844±3091.5

For breeding of the predatory mites seedlings of the same age as above were used. Each of 30 seedlings at each age group was introduced with 75 coconut mites and left for 3 weeks under a temperature of 27^0 C and 70-80% RH. After 3 weeks 5 female deutonymphs and a male of *N. baraki* were introduced on to each seedling. Ten seedlings of each age were dissected at 1, 2 and 3 weeks after introduction of predatory mites and recorded the number of predatory mites on each. The highest numbers of predatory mites were recorded on 2-4 month aged seedlings at 2 weeks after introduction (Table 7). After 2 weeks the numbers declined in all ages of seedlings.

Table 7. *Mean number of coconut mites bred on seedlings of different ages at different intervals after introduction*

Age of seedlings	Mean number of mites ±S.E. per seedling after different intervals (days)		
	1 week	2 weeks	3 weeks
0-2 months	35.6±4.8	60.2±7.9	25.8±4.2
2-4 months	60.3±7.6	83.4±16.0	35.4±6.9
4-6 months	35.6±2.5	81.5±12.8	45.6±4.7

L.C.P. Fernando & P. H.P R. de Silva

Experiment 27.49: Effect of temperature on fecundity of *N. baraki* in the laboratory (2004)

A laboratory study was conducted to determine the optimum temperature to obtain the highest fecundity of *N. baraki.* Sixty rearing arenas of 5cm x 5cm were prepared and a female deutonymph and a male were introduced on to each. Each of 15 arenas were placed on plastic trays and kept separately in incubators at temperatures of 25±0.5°C, 28±0.5°C, 31±0.5°C and 34±0.5°C and at a Relative Humidity of 90±5%. The arenas were observed each day and the numbers of eggs were recorded until each female died. There was a significant difference among the total number of eggs in different treatments. The highest mean fecundity of 24.6 eggs was recorded in the females kept at 25°C. Mean numbers of 20.7, 21.8 and 19.8 eggs were laid at temperatures 28°C, 31°C and 34°C respectively.

L. C. P. Fernando & N. Yapa

Experiment 27. 50 Effect of presence of males on the fecundity of *N. baraki* (2004)

A study was conducted to determine the effect of the presence of males continuously and for a limited period of time on the life-time fecundity of *N. baraki.* Eighteen female deutonymphs were confined individually in arenas and in a set of 9 arenas a single male was introduced to each and the male removed after one day. In the other set a single male in each arena was left until the female was dead. The arenas were examined every other day and the numbers of eggs laid by each female was recorded until its death. The females confined with a male for a day laid a mean of 41.8 eggs while the females confined continuously with males laid an average of 64.5 eggs. The study revealed that multiple mating of females is essential to obtain a higher fecundity in *N. baraki.*

L.C.P. Fernando, I. Suwandarathne & R. Dissanayake

Experiment 27.51 Determination of a suitable arena for mass breeding of *N. baraki* (2004)

Three different types of arenas were developed by modifying the basic arena used for breeding of predatory mites and were evaluated to determine their suitability for mass production of predatory mites. The 3 arenas were a closed arena with a water barrier, a closed arena without a water barrier and an open arena with a water barrier. The arenas with the water barrier comprised of a black wax paper (9.5 cm x 5.5 cm) placed on a piece of foam of similar size having a height of 2.5 cm. The arena was placed inside a plastic box filled with water up to the level of 0.5 cm below the wax paper. Strips of tissue paper of 4 cm wide with one edge suspended in water were stretched along the periphery of the wax paper. In each arena two cover slips were placed on strands of cotton wool. The arenas without the water barrier were similar except that the wax paper and the foam was bigger (13 cm x 8 cm x 2.5 cm). The edges of the strips of tissue paper were folded upwards to line the sides of the box. The foam was thoroughly wetted to keep the tissue moist. For the closed arena a hole of 5 cm x 9 cm was cut on the lid of the box and glued with parachute cloth for aeration and to prevent escape of mites. The open arena did not have a lid.

Five arenas were used for each type and 100 *T. putriscentiae* (flour mite) were introduced on to each. *Typha* pollen was provided as food. The arenas were kept in an incubator at 27±0.5°C and 85-95% RH for 7 days for the establishment of *T. putrescentiae.* Two female deutonymphs and one male of *N. baraki* were introduced on to each arena and maintained in the same conditions. The number of predatory mites in each arena was counted every 7 days up to 3 weeks. The increase in the number of predatory mites when reared on the three types of arenas at 21 days was compared. There was a significant difference ($P<0.01$) among the three types of arenas. The highest mean number of predatory mites of 48.0±12.2 was recorded in the closed arena without a water barrier. From the closed arena with water barrier and open arena with water barrier mean numbers of 31.0±6.5 and 27.6±1.5 predatory mites were recorded respectively. The weekly increase in the numbers of predatory mite is shown in Fig. 2. The highest number of predatory mites was obtained when reared on closed arena without a water barrier, and is therefore recommended for use in mass breeding.

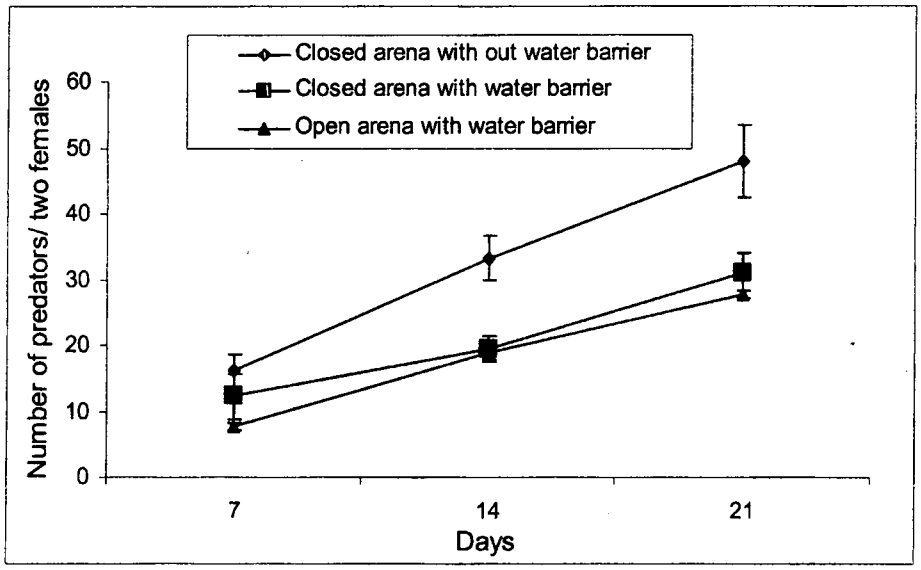

Fig. 2: *Population increase of N. baraki reared in three types of arenas over three weeks*

L. C. P. Fernando & M. Kumari

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

From the previous studies it was determined that *N. baraki* could be mass bred in the laboratory on the host *T. putrescentiae* on an arena without a water barrier as described in the experiment 27.49. *T. putrescentiae* could be reared conveniently on a mixture of rice bran and wheat flour. Mass breeding of the predatory mite was initiated in an air-conditioned insectary room at 26±2^{0}C. To study the breeding rate of *N. baraki* in the above conditions 17 arenas were randomly selected from the mass breeding culture and the number of motile predatory mites and their eggs were counted weekly up to 3 weeks after introduction. Two females and one male *N. baraki* have been introduced on to each arena. Two female predatory mites produced a mean number of 31.0±2.3 motile stages and eggs in 3 weeks showing that mass rearing could be done satisfactorily. However, the method requires close supervision and regular maintenance of arenas, and is labour intensive. Moreover, contaminations are possible if strict sanitary conditions are not maintained. The method needs to be improved to overcome these restrictions.

L. C. P. Fernando, K. F. G. Perera, D. .C .L Hapuarachchi & P.H.A.R de Silva

Experiment 27.53: Survey to determine distribution of *N. baraki* and *N. paspalivorus* (2004)

Earlier studies showed that both *N. baraki* and *N. paspalivorus* are present in Sri Lanka. Therefore, a study was initiated to determine the distribution of the 2 species in different coconut mite affected areas. Fifteen affected nuts from Puttalam and Madurankuliya (Puttalam District), Rajangane (Anuradhapura District), Madampe, Kurunegala and Narammala (Kurunegala District), Polonnaruwa (Polonnaruwa District), Mannar (Mannar District) and Gampaha (Gampaha District) were collected at 3-monthly intervals and the total number of predatory mites was recorded, and 10 mites were mounted on microscopic slides to determine the species. The study is being continued.

L.C.P. Fernando, A. D. N. T. Kumara, R. Dissanayake & D. Appuhamy

Experiment 27.54: Studies on the imported predatory mite *Proctolalaeps bickleyii* (2004)

A culture of a predatory mite of coconut mite *P. bickleyii* was imported from Brazil in August 2004. This predatory mite has been found on the coconut mite infested nuts in Brazil and thought to be a prospective candidate for biological control of coconut mite. A preliminary study was initiated to investigate whether *P. bickleyii* is a prospective candidate for biological control of coconut mite in Sri Lanka. Since *P. bickleyii* has not been reported from Sri Lanka, its interactions with other organisms, especially, the local predatory mite and its ability to enter underneath the bracts of infested coconuts needed to be investigated. Preliminary observations revealed that *P. bickleyii* feeds on the local predatory mite. In order to determine the ability of it to enter under the perianth, 2-6 month old infested nuts were picked and placed on individual arenas with known number of nymphs and adults of *P. bickleyii* for up to 12 hours in the laboratory. It was revealed that only about 8% of the mites (both nymphs and adults) were found under the perianth. Studies are being continued.

L.C.P. Fernando, M. Kumari & R. Dissanayake

Experiment 27.42: Survey to determine natural incidence of *Hirsutella thompsonii* in different infested areas (2002)

The survey conducted in 12 Coconut Development Officer (CDO) ranges of Puttalam, 6 ranges in Kurunegala, 3 ranges in Anuradhapura and 4 ranges in Gampaha Districts was completed. The results revealed that the fungus is present in all districts. The percentage of nuts with the fungus and percentage of infected nuts was significantly higher in the Kurunegala District than in others (Table 8). However the incidence of the fungus in all districts is low.

Table 8. *The percentage of nuts with H. thompsonii and the percentage of mites infected in four districts and comparisons among districts and CDO ranges*

District	No. CDO ranges	Total no. nuts	% nuts with the fungus	Comparison among ranges	% mites infected	Comparison among ranges
Puttalam	12	368	2.72 ± 3.12^{b}	**	0.64 ± 0.92^{b}	ns
Kurunegala	6	159	5.56 ± 11.82^{a}	***	4.62 ± 4.96^{a}	ns
Anuradhapura	3	80	2.56 ± 3.85^{b}	na	0.13 ± 0.19^{b}	na
Gampaha	4	90	2.22 ± 2.50^{b}	na	0.28 ± 0.48^{b}	na
Significance			***		***	

** = P<0.00, ***=P<0.001, ns= not significant, na= not analysed

L.C.P. Fernando, I. Rubasinghe, P. Manoj & T. Bandara

Experiment 27.55: Effect of *Hirsutella thompsonii* on predatory mite *N. baraki* (2003)

Twenty rearing arenas were prepared for rearing of predatory mites. The arena consisted of a 5 cm x 5 cm black paper waxed by dipping in hot bees wax and laid on 2.5 cm thick foam of the same size. The foam was placed in a 9 cm diameter petri dish filled with water up to 2 cm height of the foam. Tissue paper strips of 2.5 cm wide with one edge suspended in water were stretched around the periphery of the wax paper to discourage escape and provide drinking water. Fifty adult predatory mites were placed on a 15-day old culture of *H. thompsonii*. The culture consisted of mycelium and conidia. The predatory mites were allowed to walk on the culture for one hour. Five inoculated mites were placed on each of 10 arenas. Another 50 predatory mites which were not inoculated were placed in 10 arenas at a rate of 5 in each as the control. Each arena was provided with prey mites as food. Arenas with treated and untreated predatory mites were placed separately and incubated at a temperature of 27±0.5 °C and 85-95% RH. Arenas were checked every two days for up to 2 weeks and numbers of live and dead mites were recorded.

A second experiment was carried out in which the mites were inoculated by allowing them to swim in a 1.5 x $10^7 ml^{-1}$ conidial suspension of *H. thompsonii* for 30-60 s. The mites used for the control treatment were allowed to swim in sterilized water. The numbers of predatory mites used and the procedure followed was similar to that of previous experiment.

Dead mites were removed from the arenas and incubated at 100% RH for one week and observed under a phase contrast microscope to determine presence or absence of infection. In both "walk" and "swim" methods no dead predatory mites were observed in treated arenas although a few had escaped (Table 9). The dead mites in the untreated arenas were not infected by the fungus. The results clearly revealed that *H. thompsonii* does not infect *N. baraki*.

Table 9. *Percentages of live and dead mites, two weeks after treatment with H. thompsonii by "walk" and "swim" methods*

Treatment	% live mites	% dead mites
"Walk" method		
Treated	90	0
Untreated	88	0
"Swim" method		
Treated	92	0
Untreated	86	6

L. C. P. Fernando, I. Rubasinghe, S. Jayasekara & T. Bandara

Experiment 26.56: Comparison of four isolates of *H. thompsonii* for the management of coconut mite in the field (2003)

The experiment envisages determining the most effective isolate of *H. thompsonii* with respect to mortality of coconut mite and predatory mite, persistence of the fungus in the field and reduction in mite damage. Single spore cultures of Sri Lankan isolates H/2, H/3, H/8 and H/9 obtained from CABI Bioscience were mass cultured on boiled rice. Five hundred grams of raw rice was washed, partially cooked and placed in polypropylene bags and autoclaved for 30 min. For each isolate 12 bags were prepared. Seventy five ml of the liquid medium containing mycelium and spores were introduced to each respective bag, mixed well with the rice and sealed. The cultures were stored at 27°C for 14 days. The fungus grown on rice was extracted in water and spore suspensions of 5 x 10^6 ml^{-1} were prepared from each isolate for field application.

Each of 36 coconut mite infested palms was selected in 2 estates in Madurankuliya. In each palm 1-5 month old bunches (from the most recently opened inflorescence) were tagged and the total number of nuts and the number infested nuts in each were recorded. Twelve palms were used for each treatment including the control. Set of 6 palms in each treatment was used for assessing the mite population and incidence of the infection while the other 6 palms were kept for recording the damage assessment. In one estate isolates H/2 and H/3 were treated and in the other H/8 and H/9 were tested. Spore suspensions were mixed with 2 % detergent and 300 ml solution and applied on infested bunches of each palm using a hand sprayer. The treatment was repeated 2-weeks later. The numbers of live coconut mites and predatory mites, number of dead predatory mites and infection on dead coconut mites and predatory mites in 2 nuts of 4-month old bunches and damage assessment in tagged bunches are being recorded.

L.C.P. Fernando, P. Manoj, T. Bandara, C. Senarathne & N.G. Premasiri

Experiment 27. 56: Field evaluation of carbosulfan 20% against coconut mite (2004)

Preliminary results indicated that application of carbosulfan SC reduces both mite population and the damage in newly developing bunches over time. Therefore, a large block was selected to verify the efficacy of repeated applications on population levels and the damage. Palms in a block of one acre were selected for spraying marshal at the rate of 4 ml per litre. Root feeding was conducted on 30 palms at the rate of 10 ml per palm. A separate untreated block was maintained as the control. The chemical was applied at monthly intervals. Total population of coconut mite, the number of predatory mites in the fourth bunch and the percentage of damaged nuts of the same bunch was assessed.

The total number of mites in the fourth bunch did not decrease over time as expected (Fig. 3). Further, there was a decline in the number of predators in all blocks including the control (Fig. 4). There was a fluctuation of the degree of symptom initiation over time (Fig. 5). Having taken all results in to consideration, it is not appropriate to recommend marshal for the management of coconut mite at this stage. A final decision on the recommendation will be made after collecting one year yield data to determine whether there is at least an effect on the final yield as the chemical may have affect on the populations on the developing nuts and thus hinder the development of symptoms.

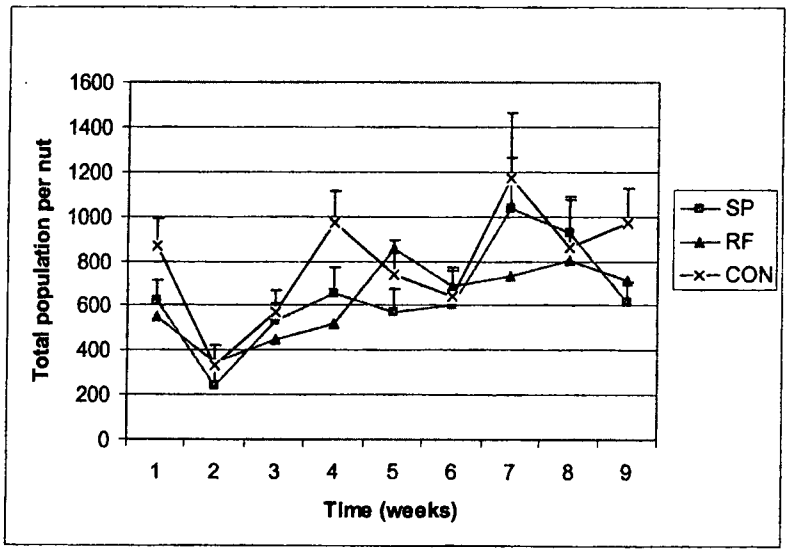

Fig. 3. *Variation in the total number of mites in different treatments (SP-spraying 4ml/lit, RF-Root feeding at 10 ml/palm, CON – control)*

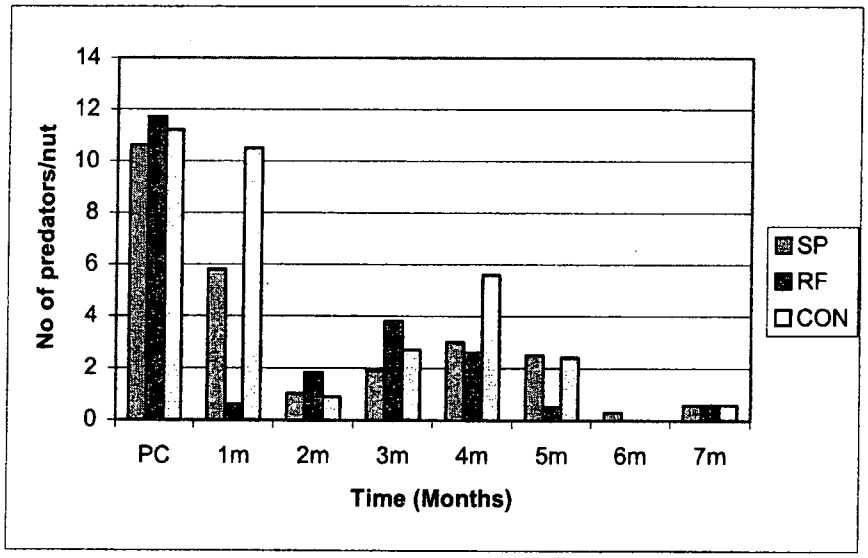

Fig. 4. *Number of predators per nut (SP-spraying 4ml/lit, RF-Root feeding at 10 ml/palm,CON – control)*

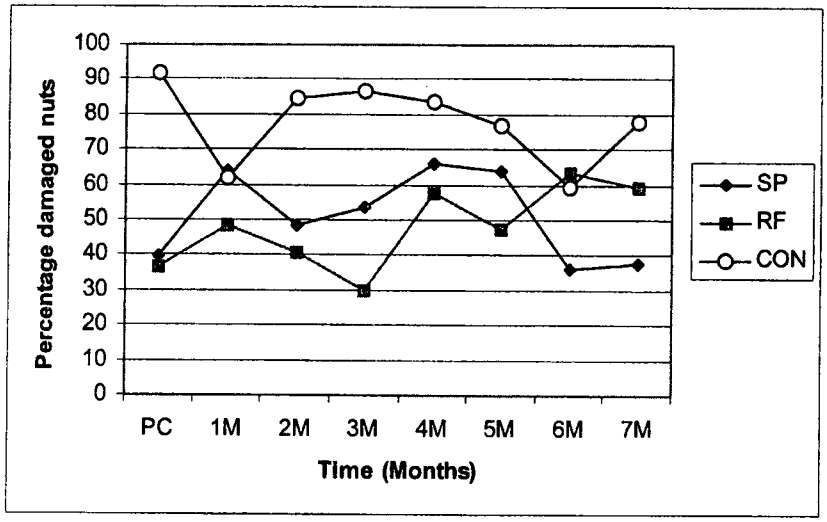

Fig. 5. *Presence of damage symptoms in the fourth bunch (SP-spraying 4ml/lit, RF-Root feeding at 10 ml/palm, CON – control)*

I.R. Wickramananda, S.R. Sarathchandra, A.D.N.T. Kumara , D. Appuhamy & R.G. Caldera

Experiment 27.57: Preliminary field testing of soybean oil against coconut mite (2004)

A preliminary field study was conducted to determine the efficacy of soybean oil against coconut mite. The chemical was sprayed on to bunches at two dilutions i.e. 5 ml and 10 ml per litre. Percentage mortality, reduction in population of coconut mite, and appearance of damage symptoms in the proceeding 4th bunch at the time of recording were considered. It was difficult to establish that the product was effective as there was no substantial increase in the mortality (Figs. 6, 7 & 8). Also the predatory mite population was affected (Fig. 9). Therefore, the chemical was not selected for large scale testing.

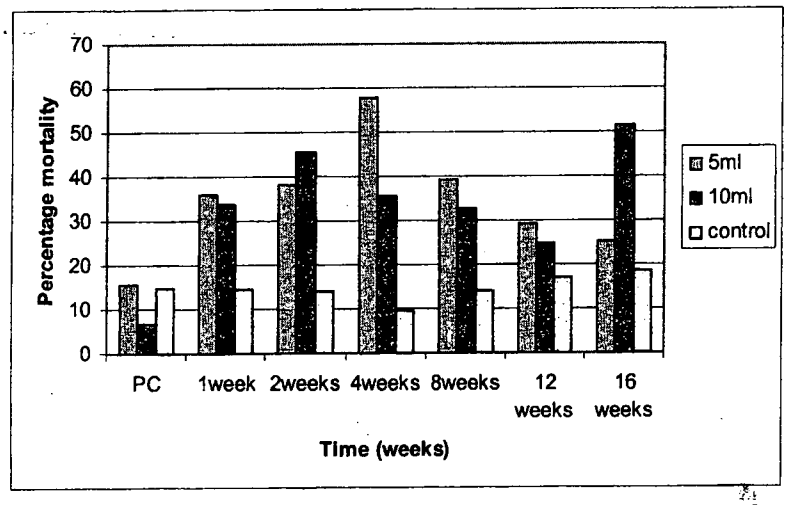

Fig. 6. *Percetage mortality of coconut mite at different time intervals after treatment with sparrow oil.*

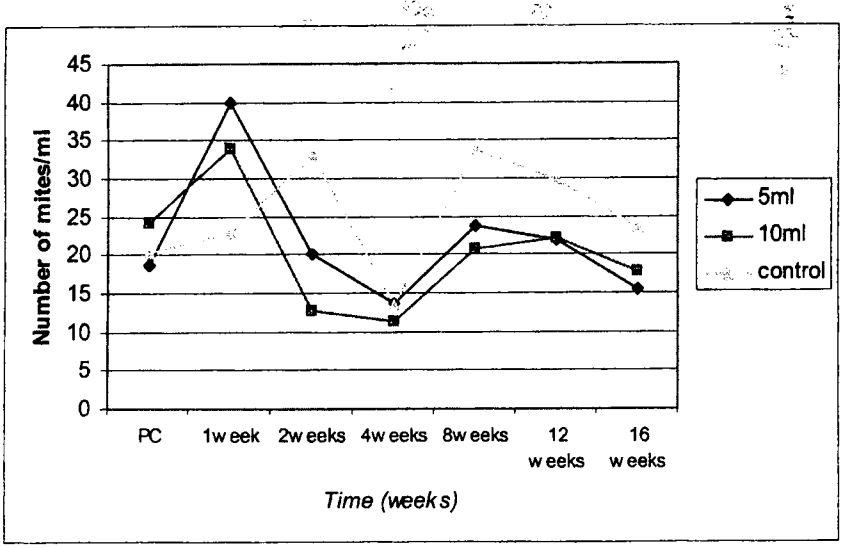

Fig. 7. *Variation in population of mites on the nuts over time*

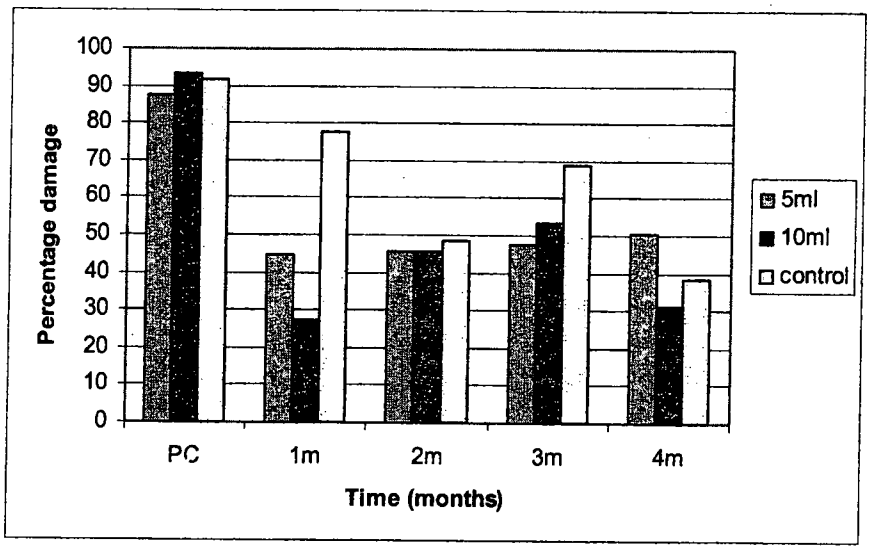

Fig. 8. *Percentage damaged nuts in the fourth bunch over time*

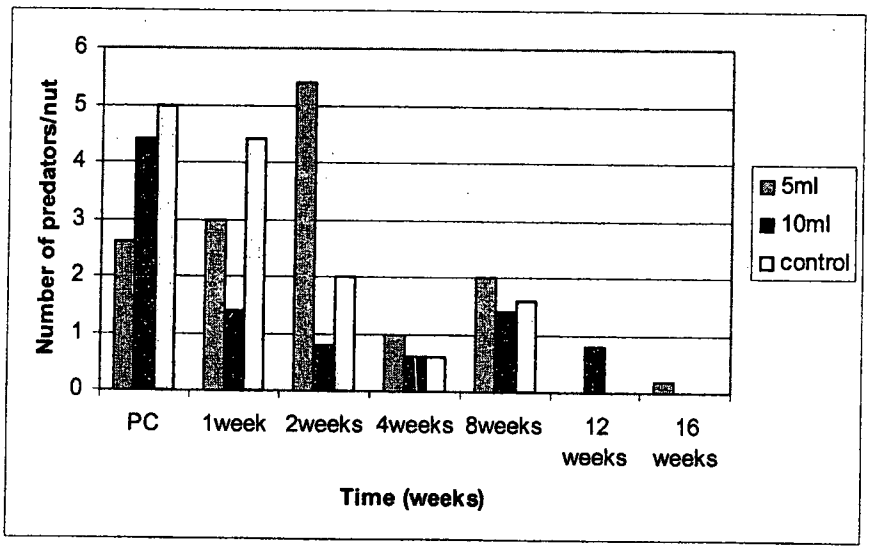

Fig. 9. *Number of predatory mites in different treatments*

I.R. Wickramananda, A.D.N.T. Kumara S.R. Sarathchandra, D. Appuhamy & R.G. Caldera

Experiment 27.58: Preliminary field testing of sparrow oil (2004)

Sparrow oil, a petroleum spray oil obtained from India was evaluated in a preliminary field study. The oil was sprayed on to bunches at two dilutions i.e. 5 ml and 10 ml per litre. The maximum mortality achieved was 35% at the rate of 10 ml per litre. Hence it was concluded that the chemical is not effective and therefore not selected for large scale testing.

I.R. Wickramananda, D.Appuhamy & R.G. Caldera

Experiment 27.48: Effect of used engine oil on coconut mite (2003)

Previous studies showed that application of a 30% mixture of used engine oil was effective in controlling coconut mite. Therefore, a pilot trial was conducted to determine the effect of applying 30% mixture of used engine oil on the incidence of damage after treatment and at harvest, advancement of damage to newly developing bunches and the frequency of application. The trial was conducted in each of one-acre blocks at Udappuwa, Mampuri and Anuradhapura. In each palm 2-5 month old bunches were treated with used engine oil and the treatments were repeated at 1, 2 and 3-monthly intervals at Udappuwa, Mampuri and Anuradhapura respectively. At the subsequent round of treatment, all previously untreated bunches up to 2-month old bunches were applied with used oil. In each plantation 20 treated palms in the one-acre block and 20 untreated palms adjoining the treated block were marked. In each of the 20 selected palms, 2- and 4-month old bunches were marked before the first round of treatment and the total number of nuts in each bunch was recorded. In the untreated palms, 2 and 4 month old bunches were similarly marked and total number of nuts were recorded. Prior to the second round of treatment, the total number of nuts and the number of damaged nuts (fresh and discontinued) in the previously marked bunches were recorded. At the second round of treatment the 2- and 4-month old bunches present at the time of application were marked and the data recorded as for the first round. During the first 5 rounds of treatments in all three plantations the total number of nuts and damaged nuts in the two untreated bunches immediately before the youngest treated bunch were recorded. When the treated bunches were harvested, the nuts in the marked palms were collected separately and were categorized into 5 groups (A-E) according to the degree of damage. They were undamaged and normal sized nuts (category A), damaged and normal sized nuts (category B), damaged and smaller sized nuts (category C) and undamaged and smaller sized nuts (category E). Data for seven picks were recorded.

The application resulted in discontinuation of damage and very low percentage of fresh damage on treated bunches and more importantly the treatment resulted in a large proportion of nuts without damage compared to the palms in untreated control (Fig. 10). Also results on harvest data shows that the percentage of undamaged and normal sized nuts is higher in treated palms than on untreated ones (Table 10). The results are being statistically analyzed.

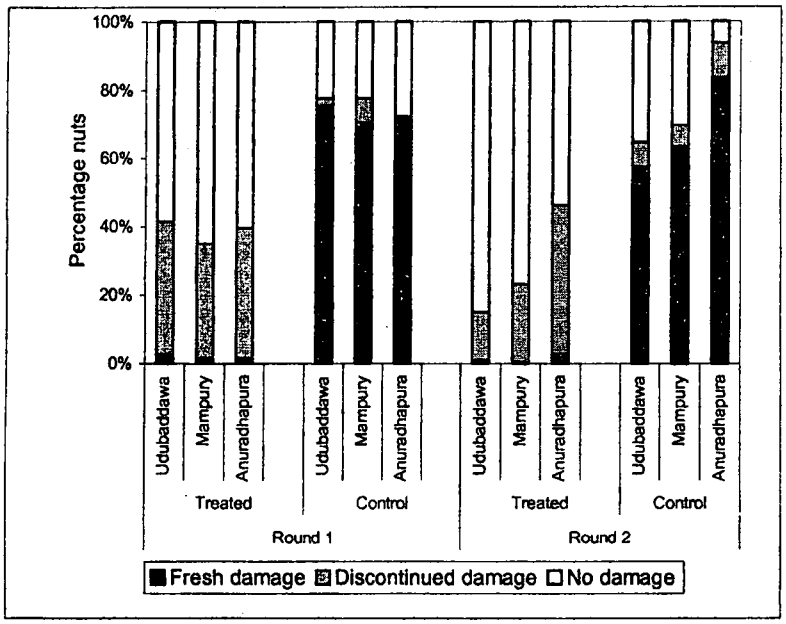

Fig. 10. *Percentage of nuts with fresh damage, discontinued damage and without damage in treated and untreated palms after two rounds of treatments at Udubaddawa, Mampuri and Anuradhapura.*

Table 10. *Mean percentage of undamaged and normal sized nuts (category A), damaged and normal sized nuts (category B), damaged and smaller sized nuts (category C) and undamaged and smaller sized nuts (category E) in selected palms in seven picks at Udubaddawa and Anuradhapura.*

Site	Treatment					Control				
	A	B	C	D	E	A	B	C	D	E
Kuliyapitiya	69.25	21.50	1.63	0.19	0.52	15.00	71.49	9.30	1.83	0
Anuradhapura	57.45	38.20	2.61	0.48	1.26	12.30	70.09	12.83	4.66	0.11

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

PROJECT 28: STUDIES ON THE ASSOCIATION OF PARASITIC NEMATODES AND FUNGI WITH LEAF SCORCH DECLINE OF COCONUT (2001)

Experiment 28.1: Population dynamics of the burrowing nematode *Radopholus similis* (2001)

The experiment was continued to study the fluctuation pattern of the burrowing nematode populations in the roots and the soil of the root zone of LSD affected palms and healthy palms. Each of 15 affected palms, 5 apparently healthy palms and 5 seedlings from Arachchikattuwa, Walpita and Bandirippuwa estate and each of 15 palms from sites free from LSD (Nawagattegama, Kurunegala and Kegalle) were sampled at 3-monthly intervals.

The presence of nematodes in unaffected sites was negligible compared to the affected sites. At the sites in Kegalle and Nawagattegama a mean numbers of 0.7 and 0.2 nematodes were found respectively. Generally, in the affected sites, nematodes were present in the soil at all sampling occasions. The mean numbers of nematodes found in roots were negligible in unaffected palms compared to the affected palms. They were found mainly in the cooler rainy months from October to December as in the previous years (Table 11). The experiment was completed and results are being analysed.

Table 11. *Mean number of nematodes in the roots of LSD-affected palms and apparently healthy palms in affected sites.*

Location	Affected				Apparently healthy				Seedlings			
	Dec.	Ap.	Jun.	Oct.	Dec.	Ap.	Jun.	Oct.	Dec	Ap.	Jun.	Oct.
Aratchchikattuwa	0.53	0	0.9	0	0	0	0.6	0	0	0	0	0
BE	0.6	0	0	0	0	0	0	0	0	0	0	0
Walpita	0.8	0	0	0	0	0	0	0	0	0	0	0

L.C.P. Fernando, P.H.A.P. Siriwardena & W.W.N. Fernando

Experiment 28.3: Effect of introducing cell sap into test plants (2003)

The method of introducing the cell sap to maize plants in the previous year's experiment was modified by gradually drenching 10 ml of the sap content on to leaf axils of the plants. The experiment was intended to determine whether scorching symptoms are produced on treated plants following treatments. Cell sap extracted from roots of affected palms, apparently healthy palms and seedlings in affected estates and healthy palms of unaffected estates were introduced on to 60, 12, 12 and 36 plants respectively. Also each of 10 plants were introduced with distilled water and left as controls. Application was repeated 4 times at 10 week intervals. Observations revealed that plants treated with affected sap contents showed scorch symptoms similar to Leaf Scorch Decline, but the experiment could not be continued due to heavy drought conditions.

Similarly, 11 month old embryo-culture coconut seedlings were introduced with cell sap of affected and unaffected palms. Although scorching was observed in some treated palms conclusions could not be made as the culture mediums of those seedlings were contaminated with fungi.

L.C.P. Fernando, P.H.A.P. Siriwardena & W.W.N. Fernando

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

Experiment B26.5.5: Evaluation of Contaf 5EC, Folicur EW250 and Bavistin for the management of leaf rot in the field (2002)

The experiment in the previous year suggested that drenching of fungicides were promising in managing the disease than trunk injection. Therefore, a field study was conducted in an estate in Matara district to determine the suitability of drenching Contaf, Folicur and Bavistin on remission of disease symptoms. One liter of each fungicide solution (10ml in 1 l water) was drenched on each of 10 affected palms for 6 times at monthly intervals. Ten affected palms were kept untreated. After the applications the degree of damage on newly emerged leaves was assessed. The results showed that none of the chemicals had completely controlled the diseases. Contaf and Folicur have reduced the damage intensity considerably and Folicur was the best treatment (Table 12).

Table 12. *Percentage of leaves in each damage category (healthy, <25% damage, 25-50% damage, >50% damage) in each treatment*

Treatment	Percentage leaves (n=70) in each damage category			
	Healthy	<25%	25%-50%	>50%
Contaf	25.7	37.1	17.1	20.0
Folicur	24.2	37.1	30.0	5.7
Bavistin	7.1	14.2	31.4	35.7
Control	7.1	14.2	31.4	38.5

L.C.P. Fernando, I. R. Wickramanada, P. Manoj, K.F. G. Perera & N. G. Premasiri

3. CROP PROTECTION SERVICES

Incidences of pests and diseases

Sixty five pest incidences were reported during the year. Appropriate control measures were recommended.

Biological and chemical control

a. Coconut caterpillar: All infestations were successfully controlled by release of parasitoids and limited application of insecticides. 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 3093 vials were sold to the growers and CCB regional offices.
c. Chemical control: Issue of monocrotophos directly by CRI was restricted only to CRI estates and experimental blocks. A total of 32.1 l of monocrotophos was issued. The requirement of the growers was supplied to the Coconut Cultivation Board.

4. TRAINING AND EXTENSION ACTIVITIES

Extension activities

Divisional staff participated as resource personnel in various training programmes arranged by the CRI and other Institutions. Students from universities, technical colleges, schools and growers visited the Division during the year.

Table 13. *Release of parasitoids in different provinces for the management of coconut caterpillar*

Parasitoid	Western	North western	Southern	Eastern	Sabaragamuwa	Total
Eriborus trochanteratus	1000	36,350	1900	500		39,750
Bracon hebetor	7000	4,44,350	10,500	75,000	0	5,36,850
Goniozus nephantidis	2250	1,04,750	0	14,750	0	1,21,750
Brachymeria nephantidis	500	1,11,900	1950	8050	0	1,22,400
Total	10,750	6,97,350	14,350	98,300	0	8,20,750

Acknowledgements

I am grateful to the staff of Crop Protection Division for their dedication 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 to the contract staff for their hard work in the coconut mite research programme. Sincere thanks are extended to the Head and staff of the Biometry Division for the assistance given in designing experiments and analysis of data, and the Head, Tissue Culture Division for providing embryo culture seedlings for experiments. I acknowledge the funds provided by the Council for Agricultural Research Policy, Coconut CESS and the Department for International Development for conducting coconut mite research. I thank Professor J.G. de Moraes and the Government of Brazil for arranging to send us the exotic predatory mite.

REPORT OF THE BIOMETRY DIVISION
Head – T. S. G. Peiris, Ph D (FRS)

1. GENERAL

The division continued to assist the research divisions in designing field experiments and questionnaire for field surveys, sampling methods for socio economics surveys, statistical analysis, and interpretation of results. Various types of alternative experimental designs such as single palm plot designs, nearest neighbour designs, restricted randomized block designs, and scattered block designs were recommended for field experiments in coconut.

The division continued to assist the staff in computer usage, developing computer programmes, database management and maintaining computers and network system.

The predicted annual national coconut production (ANCP) based on the statistical model, which combines climate and technology effects, was 2715 million nuts for 2005. Whereas, the projected nut requirement predicted for domestic usage and industries was 2785 million nuts for 2005. The ANCP for 2004 gave 7.6% error as against the actual production of 2600 million nuts.

An island wide consumer survey on the use of coconut oil and fresh coconut was started during July as those two indicators which contribute significantly in deciding the actual annual national coconut production. Actual national production has hardly changed over the years. The rate of coconut consumption per family per month was the highest (4.9 nuts) during August in Kurunegala. Oil consumption was highest (0.61 bottles) during July in Gampaha district.

Based on the yield records acquired from various estates in Hambantota, Gampaha, Puttlam and Kurunegala districts the yield per acre during the year 2004 was 2360, 3016, 2944 and 1645 nuts respectively.

The analysis of long-term rainfall and temperature in Hambantota district on weekly basis revealed that the expected future climate would not be suitable for coconut cultivation in Hambantota area and emphasized that farmers should be encouraged for rainwater harvest during high intensive rainy periods.

On analysis of production and import data revealed that the rate of consumption of coconut oil per person per year has dropped from 6.6 bottles in 2003 to 2.06 bottles in 2004. The corresponding rate for vegetable oils (substitute imported oil) has also dropped from 9.55 bottles in 2003 to 8.82 bottles in 2004.

The meteorological stations at Bandirippuwa Main Research Centre, Ratmalagara Research Centre and Genetic Research Centres at Ambakelle and Maduru Oya were maintained satisfactorily. Computerization of rainfall data at Research Centres at Poththukulama and Walpita and Pallama Genetic Research Center was started during the year. Climate data were issued for various users and organizations. Rainfall during the first four months of 2004 lower than the corresponding period in 2003 in all of the stations and rainfall during May to August is higher than the corresponding period in 2003. Therefore, reduction of yield during the first two picks in 2005 and increase of yield during third and forth pick in 2005 with respect to corresponding period in 2004 could be expected in most of the coconut growing areas in the island.

2. ASSISTANCE IN COMPUTER RELATED WORK

1. The website of the CRI (www.cri.lk) was maintained and updated several times.

T S G Peiris

2. Continuous assistance was provided to all divisions on the use of Internet system and Emails.

S S Rajapakse, J D J S Kularatna & W S Wickramarachchi

3. Coordinated the work conducted for developing programmes, maintaining the databases on Personal Management System and Transport System in the Establishment Division.

W S Wicramarachchi & S S Rajapakse

4. Assistance was provided for hardware and software maintenance, and co-ordinated activities of computers in the Institute.

S S Rajapaks, W S Wickrmarachchi & J D J D Kularatna

5. Computerization of all the weather variables recorded at seven meteorological stations continued throughout the year. The computerized data were sent to the Meteorology Department, Colombo.

W B P Fernando, J H U Jayamaha & W M K M Herath

6. Web based programs were developed to maintain monthly rainfall of various locations and to maintain yield records of CRI estates.

W S Wickrmarachchi

7. Computerizing & processing of information of the Medical Aid Scheme and climatological data of the CRI research stations were continued.

J D J S Kularatna

8. Two Proceedings and an Abstract book of the International Coconut Conference held in Colombo to mark the 75th anniversary of the CRISL were edited and published.

T S G Peiris, C S Ranasinghe & U I Abeysinghe

3. STATISTICAL ASSISTANCE

Analyses of various long-term and short-term field experiments were carried out. Undergraduates and postgraduates from various universities were provided with statistical analysis in respect to their projects.

T S G Peiris, J D J S Kularatna & W E R C Fernando

Four postgraduate theses on Applied Statistics were supervised. Of those three were related to coconut research. Various papers of the referred journals were revived.

T S G Peiris

4. RESEARCH PROJECTS

PROJECT 1: Annual National Coconut Production (ANCP)

A new statistical model to predict ANCP, which integrate climate effect and technology effect, was developed (R^2=0.94) using data from 1950-2001. The technology effect was estimated using a log-linear trend model and climate effect was estimated using three-monthly seasonal rainfall in different agro-ecological regions in principal coconut growing areas. This is a good improvement than the previous model as quarterly rainfall explained more of the variability of ANCP than monsoon seasonal rainfall in principal coconut growing areas. The model is given in the equation (1). The parameters of the model were updated in order to make the model dynamic.

$$ANCP_t = \mu + \exp(\alpha + \beta_t) + \sum_{i=5}^{5} \theta i * RF_{i,t-1} \quad \text{.......................................} \quad (1)$$

From this model ANCP can be predicted 15 months in advance. That is ANCP for a given year can be predicted by October of the previous year using rainfall up to September of the previous year. Comparison of predicted and actual yields from 1998 to 2004 are given in Table 1. The predicted value for 2005 is 2715 million nuts.

Table 1. *Comparison of predicted values of ANCP using new statistical model*

Year	Million nuts		% error
	Actual	Predicted	
1998	2540	2628	3.5
1999	2830	2871	1.4
2000	3096	3000	-3.1
2001	2600	2764	6.3
2002	2480	2608	5.2
2003	2605	2589	-0.6
2004	2600	2900	11.5
2005	-	2715	

T S G Peiris

PROJECT 2: Consumer Survey of usage of fresh Coconuts and Coconut Oil

The actual annual national coconut production is estimated through an indirect method which involves the local consumption rate of fresh nut and coconut oil. These rates are issued by consumer survey conducted by once in four years by the Department of Census and Statistics. As these rates are hardly changed over the years, unrealistic values of ANCP can be obtained. By changing the fresh nut consumption by 5 nuts/person/year, the actual ANCP would change by 90 million in nuts, if the population is 19.0 million. If the fresh nut consumption is changed by 5 nuts and coconut oil by half a bottle (0.325 kg) the actual ANCP would change by 160 million nuts. Therefore in order to obtain more precise values for local consumption rates on annual basis, a consumer survey was started during July and it is expected to continue annually for a long-period. The expected sample size is about 10,000 which consist of randomly selected 10 families from each GN divisions in all Divisional Secretaries of Sri Lanka. Once questionnaires are handed over to the Grama Niladarys through Additional Divisional Secretaries, they posted the collected data to the CRI. Already five weeks data have been collected, but it is expected to extend this for another 2-3 months. A certificate from the CRI is issued in appreciation of the support given by the Grama Niladarys. Based on the data received during the year the average consumption pattern in 6 district are given in (Table 2).

Table 2. *Rate of fresh nut and coconut oil consumption based on consumer survey*

District	Month	Consumption rate per person per month (Mean ± SE)	
		Fresh nuts	Coconut oil (bottles)
Gampaha (221)	Aug	9.73 ±0.29	0.59 ± 0.02
	July	12.28 ± 0.78	0.61 ± 0.05
Hambantota (711)	September	11.79 ± 0.20	0.37 ± 0.01
Kegalle (379)	November	9.53 ± 0.19	0.36 ± 0.01
Kurunegala (214)	August	14.93 ± 0.42	0.50 ± 0.02
	July	12.87 ± 0.40	0.49 ± 0.02
Puttlam (817)	December	10.93 ± 0.17	0.48 ± 0.01
Ratnapura	September	10.44 ± 0.18	0.48 ± 0.01

(Number of house holders are shown in parenthesis)

T S G Peiris, W K M K Herath, W M L G Fernando & J D J S Kularatna

PROJECT 3: Variation of Coconut Yield between Districts

As we do not have national database on nut production in different seasons and districts, a survey was initiated during July 2004 to acquire yield data from the coconut growers. These data would be useful to get a better estimate for the annual national coconut production (ANCP), to find the contribution to the ANCP from each district and to predict ANCP at bi-monthly intervals. Based on the data acquired during the year the picking average nut production in 4 districts is given in Table 3.

Table 3. *Observed yield in 2004 (nuts/palm) in different districts*

District	Pick 1	Pick 2	Pick 3	Pick 4	Pick 5	Pick 6
Puttlam (55)	12.0	13.9	13.8	11.6	9.2	7.0
Gampaha (33)	8.7	10.9	11.1	9.2	6.7	4.0
Kurunegala (115)	7.1	8.6	8.3	7.6	5.3	3.5
Hambantota (20)	8.0	9.7	10.0	n/a	n/a	n/a

(Number of estates used is shown in parenthesis.)

Based on the total area under coconut of those estates annual yield per acre of the four districts Puttlam, Gampaha, Kurunegala and Hambantota was estimated as 2944, 3916, 1645 and 2360 nuts respectively.

T SG Peiris, W K M K Herath, W M L G Fernando & J D J S Kularatna

PROJECT 4: Nuts Requirement for the Coconut Industry in 2005

Considering past trend of nut utilization in Sri Lanka and world demand for coconut kernel based products, nut requirements for different sectors during 2005 were estimated using statistical models. Total consumption was estimated at the rate of 95 nuts/person/year and exponential growth rate of population. Demand for DC was modeled using world demand and Philippines DC Production as predictor variables.

Table 4. *Projected nut requirement (in million) for different stake holders*

Activity	Nuts in million
Local consumption as fresh nuts	1437
Coconut oil for local use	212
Export demand for DC	440
Copra	86
Coconut cream and coconut milk powder	55
Fresh nut export	27
Coconut oil export	24
Seed nut requirement	4
Total	2785

As the estimated national coconut production for 2005 is 2715 million, there will be a shortage of about 70 million nuts to fulfill all the requirements. As there was more dry days during the first quarter of 2004 in all coconut growing regions low production would be expected during the first two picks in 2005 compared to the corresponding picks in 2003. However, as the rainfall has increased during May to August in all areas the production in pick 3 and pick 4 during 2005 would expected to be higher.

T S G Peiris & U I Abeysinghe

PROJECT 5: Impact of Coconut Mite on the Coconut Industry

A survey was carried out during 2003/2004 in the five selected coconut mite infested zones (MIZ) namely Anuradhapura, Pollonnaruwa, Rajangane, Puttlam and Kurunegala. Sampling method was two stages stratified random sampling. Nuts harvested at bimonthly intervals from the selected palms were grouped into three main categories based on (a) status of mite damage (damaged nuts due to mite vs. undamaged nuts), (b) nut size (full priced nuts vs. half priced nuts), and (c) nut shape (normal shape, deformed and barren) resulting 12 categories. At most five nuts were selected from each of the above category (except barren nuts) and weight with husk, weight after removal of husk and weight after removal of water from nuts were taken. Linear logistic model was fitted to find the effect of different factors on the percentage of mite infestation.

Table 5. *Results of the ANOVA of the best fitted logistic model for mite infestation data*

Source	DF	Chi-square	Pr > Chisq
Intercept	1	36.05	< 0.0001
MIZ	4	459.32	< 0.0001
Nut size	1	4.61	0.0319
MIZ*Nut size	4	39.82	< 0.0001
Nut shape	2	59.02	< 0.0001
Nut size*nut shape	2	6.57	0.0374
Likelihood ratio	16	16.70	0.3990

According to the results in Table 5, it is clear that intensity of mite infestation is significantly different between MIZ, nut size, and nut shapes ($p<0.001$). The probability associated with each factor confirmed that among the three factors location is more influential on mite infestation than other two factors. The multiple comparison test confirmed that the incidence of mite infested nuts in

Kurunegala and Puttlam is significantly lower ($p<0.001$) than that in other three regions, but there is no significant difference in Kurunegala and Puttlam districts. There is no significant 3-way interaction between factors as well as 2-way interaction between location and nut shape of the 2 way interacting, the effect of interaction between location and nut size is stronger. The percentage of mite infested nuts by location and nut size is shown in Figure 1.

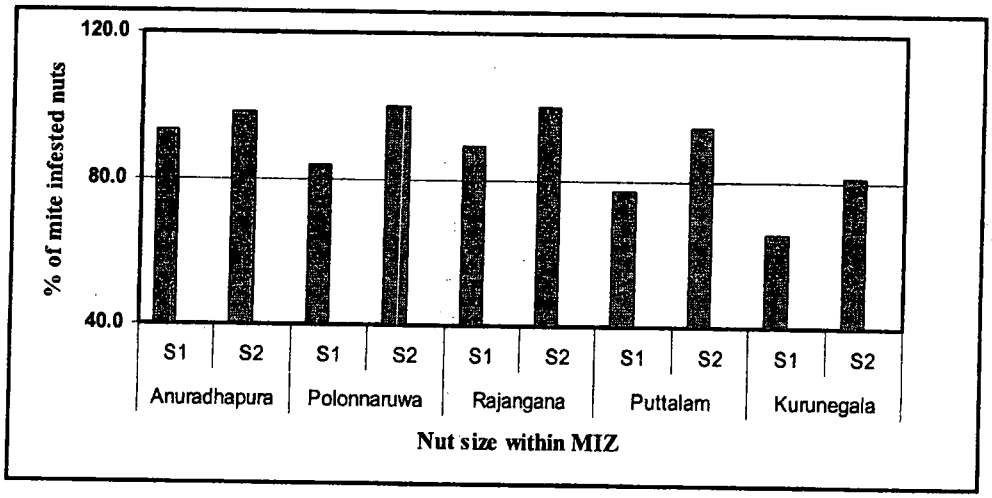

Fig 1. *Percentage of mite damaged nuts between large sized (S1) and small sized nuts (S2) within MIZ*

The intensity of mite damaged nuts is higher among small sized nuts than large sized nuts in all regions (Fig. 1). Not all nuts are infested with coconut mite and not all mite infested nuts cause economic loss to the growers. Normal sized nuts (except barren) could be sold at a normal price (full priced nuts) irrespective of mite damage. Small sized (half priced nuts) fetch a lower price while button nuts and small size deformed nuts are rejected. The nut loss due to coconut mite was defined as the percentage of mite infested nuts that can not be sold at the price of full size nut. Further, nut loss due to mite on button shedding and immature nut fall was also considered to the gross nut loss due to mite infestation. Percentage nut loss of harvested nuts varied from about 18 nuts/palm/year in Puttlam to 10 nuts/palm/year in Rajangana with a mean of 16 nuts/p/year irrespective of location (Table 6).

Table 6. *Percentage of nuts loss due to coconut mite in the selected MIZ*

Mite infested zone	Percentage of nut loss (per palm/year)
Anuradhapura	16.6
Pollonnaruwa	12.4
Rajangana	9.6
Puttalam	17.7
Kurunegela	15.4
Mean	**15.9**

Based on the detailed analysis of nut sizes and their weights the following conclusions were obtained.

- Irrespective of spatial and temporal variability, mean percentage of nut loss per mite infested palm per year was 15.9
- The reduction in the annual national coconut production (ANCP) in a given year is (2-3) % with respect to the total ANCP of the year.
- If the wholesale nut price is the loss to the coconut grower by SLR 15/-per nut selling nuts is SLR 6000/- per hectare.
- From randomly selected 10000 nuts about 200 kg of desiccated coconut is lost.
- The reduction of fresh husk weight was about 15%.

T S G Peiris, M T N Fernando & I R Wickramananda

PROJECT 6: Analysis of Climate in Hambantota District

In order to provide useful information to farmers, planners and scientists by means of comprehensive statistical analysis, different indices derived from rainfall and temperature were analyzed on annual and weekly basis using data from 1951- 2001.

The annual rainfall in Hambantota varied from 603 mm to 1825 mm with the mean of 1020 mm and median of 976 mm. The probability of annual rainfall is below the mean annual water requirement of the coconut palm of, 1125 mm (on the assumption of crop coefficient for coconut is 0.75) is 66%. There is a chance that a dry spell of at least 60 days would occur once in three years. Of the 51 years (1951 – 2001), at least three dry spells of greater than 30 days within a year has occurred in 21 years. The average annual rainfall after 1976 had dropped by 13% as compared with the mean annual rainfall prior to 1976. The amount of rainfall per rainy day (> 0 mm) showed a significant decreasing trend (Fig 2). The amount of rainfall per effective rainy day (> 5mm) also showed higher rate of decreasing trend ($R^2 = 0.43$, b = - 0.1687, $p = 0.0001$).

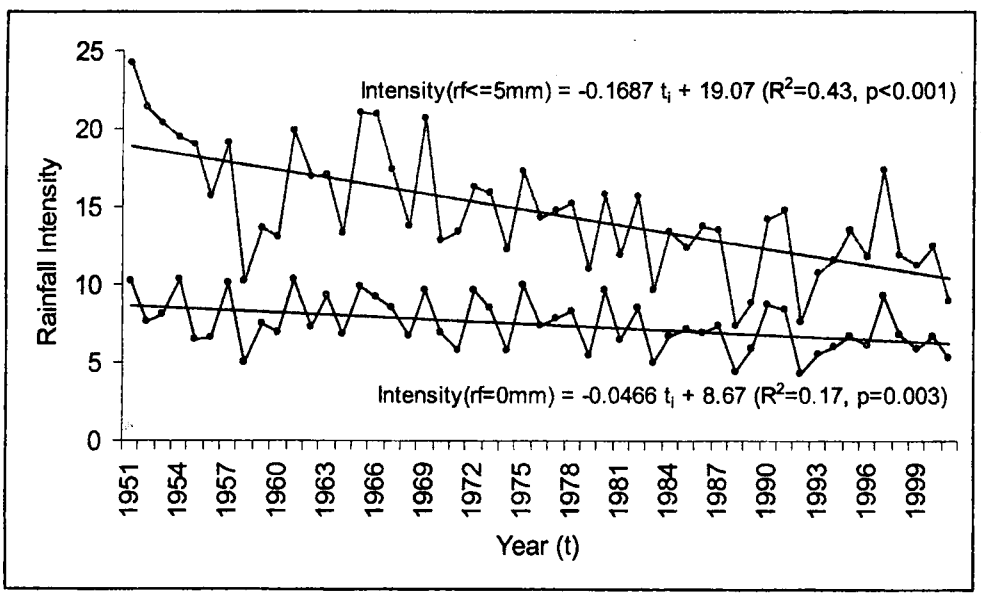

Fig 2. *Temporal variability of rainfall intensity per rainy day (rf > 0) and per effective rainy day (rf >= 5) and pattern of linear trend. The pattern of weekly rainfall changed significantly over the years.*

Table 7. *The week number and periods corresponding to the week numbers*

Week No	Weekly Period (in days)	Week No	Weekly Period (in days)
1	01 – 07 Jan	27	05 – 11 Jul
2	08 – 14 Jan	28	12 – 18 Jul
3	15 – 21 Jan	29	19 – 25 Jul
4	22 – 28 Jan	30	26 Jul – 01 Aug
5	29 Jan – 04 Feb	31	02 – 08 Aug
6	05 – 11 Feb	32	09 – 15 Aug
7	12 – 18 Feb	33	16 – 22 Aug
8	19 – 25 Feb	34	23 – 29 Aug
9	26 Feb – 04 Mar	35	30 Aug – 05 Sep
10	05 – 11 Mar	36	06 – 12 Sep
11	12 – 18 Mar	37	13 – 19 Sep
12	19 – 25 Mar	38	20 – 27 Sep
13	26 Mar– 02 Apr	39	28 Sep – 04 Oct
14	03 – 09 Apr	40	05 – 11 Oct
15	10 – 17 Apr	41	12 – 18 Oct
16	18 – 24 Apr	42	19 – 25 Oct
17	25 Apr – 01 May	43	26 Oct – 01 Nov
18	02 – 08 May	44	02 – 08 Nov
19	09 – 15 May	45	09 – 15 Nov
20	16 – 22 May	46	16 – 22 Nov
21	23 – 29 May	47	23 – 29 Nov
22	30 May – 05 Jun	48	30 Nov – 06 Dec
23	06 – 12 Jun	49	07 – 13 Dec
24	13 – 19 Jun	50	14 – 20 Dec
25	20 – 27 Jun	51	21 – 23 Dec
26	28 Jun– 04 Jul	52	24 – 31 Dec

Most of the weeks showed decline trend for rainfall. The probabilities of weekly rainfall > 0, 10, 20, 30 and 35 mm were computed (Table 7 and Table 8). The rainfall is significantly higher during the weeks 42 – 48 (19 Oct – 06 Dec) with a peak during 44-46 weeks. (02 Nov – 22 Nov) Over 30% of mean annual rainfall is received during this period. This percentage contribution from each week also showed decline trend. The probability of receiving at least 20 mm of rainfall during all the weeks 42-48 is above 50% (Table 8).

Table 8. *Mean rainfall and probability (%) of rainfall grater than 0, 10, 20, 30, 35mm*

Week No	Mean Rainfall (mm)	Probabilities (%) of rainfall				
		> 0mm	> 10mm	> 20mm	> 30mm	> 35mm
1	18.5	74.51	37.25	31.37	25.49	17.65
2	19.4	80.39	43.14	27.45	21.57	21.57
3	22.9	64.71	39.22	29.41	19.61	17.65
4	10.7	56.86	29.41	23.53	9.80	9.80
5	16.8	62.75	35.29	29.41	21.57	15.69
6	13.1	52.94	37.25	23.53	19.61	19.61
7	10.8	54.90	29.41	17.65	13.73	13.73
8	11.9	54.90	29.41	21.57	9.80	7.84
9	14.7	56.86	31.37	23.53	13.73	11.76
10	11.4	56.86	29.41	13.73	9.80	7.84
11	13.5	58.82	33.33	21.57	13.73	9.80
12	11.4	58.82	25.49	13.73	9.80	7.84
13	15.1	70.59	33.33	25.49	21.57	13.73
14	22.1	84.31	54.90	33.33	29.41	23.53
15	22.5	74.51	58.82	37.25	27.45	23.53
16	22.6	82.35	45.10	33.33	21.57	19.61
17	19.1	84.31	50.98	37.25	19.61	17.65
18	25.1	88.24	56.86	41.18	27.45	21.57
19	18.9	76.47	39.22	31.37	23.53	17.65
20	20.8	76.47	52.94	35.29	31.37	25.49
21	12.4	74.51	33.33	23.53	11.76	9.80
22	15.4	88.24	33.33	25.49	19.61	17.65
23	11.4	82.35	39.22	15.69	7.84	7.84
24	13.2	78.43	29.41	19.61	11.76	11.76
25	12.9	78.43	33.33	25.49	17.65	17.65
26	13.1	78.43	35.29	17.65	11.76	11.76
27	10.1	68.63	25.49	9.80	7.84	7.84
28	8.1	72.55	27.45	11.76	5.88	5.88
29	12.7	70.59	33.33	19.61	13.73	9.80
30	12.2	72.55	33.33	17.65	13.73	9.80
31	9.8	58.82	23.53	19.61	13.73	9.80
32	15.3	80.39	39.22	27.45	19.61	19.61
33	14.8	68.63	37.25	21.57	11.76	11.76
34	7.3	60.78	27.45	11.76	5.88	3.92
35	10.0	68.63	29.41	17.65	13.73	9.80
36	7.4	70.59	21.57	5.88	3.92	3.92
37	16.3	78.43	47.06	27.45	17.65	11.76
38	19.7	86.27	49.02	29.41	19.61	17.65
39	22.1	86.27	52.94	31.37	19.61	17.65
40	15.1	74.51	35.29	25.49	23.53	19.61
41	26.0	82.35	54.90	43.14	33.33	25.49
42	35.6	80.39	58.82	47.06	37.25	35.29
43	36.0	90.20	64.71	54.90	39.22	35.29
44	50.0	98.04	78.43	66.67	54.90	54.90
45	45.4	98.04	78.43	66.67	56.86	49.02
46	49.9	100.00	82.35	66.67	54.90	54.90
47	38.0	98.04	78.43	66.67	50.98	39.22
48	38.8	96.08	74.51	60.78	49.02	45.10
49	21.8	88.24	54.90	39.22	23.53	23.53
50	24.3	86.27	49.02	39.22	27.45	23.53
51	24.7	90.20	52.94	35.29	23.53	21.57
52	26.2	90.20	47.06	31.37	23.53	19.61

Of these weeks the probability of receiving at least 35 mm of rainfall in a week is above 50% only during 44 – 46 weeks. However, rainfall during 42 – 48 did not show any significant trend. Receiving reasonable amount of rainfall (> 20 mm) during the weeks other than above period is very uncertain. The probability of receiving at least 20 mm of rainfall in a week other than weeks 42 – 48 is varied from 10 – 35%.

Four temperature indices: (a) maximum temperature (Tmax), (b) minimum temperature (Tmin), (c) mean temperature (Tmea) and (d) diurnal temperature (Tdif). All indicators showed increasing trends for all the weeks. The trends are significant in most of the weeks. The rate of increase in maximum temperature is higher than that in other indices during all the weeks. Rainfall showed negative correlation with maximum temperature on weekly scales too.

The results confirmed that farmers in Hambantota can not depend on reserved rainy water for their agricultural purposes. The expected climate in Hambantota would not be suitable for coconut plantation. Coconut cultivation should not be promoted in this area unless alternative irrigation method is established. The change in the weekly rainfall pattern will affect the pattern of potential evapotranspiration and so the characteristics of the growing seasons of short-term and annual crops. With the increase in air temperature, in particularly maximum air temperature, the potential demand for water rise faster and reduce the length of growing periods. This will affect the different cultural practices such as land preparation, planting coconut seedling, fertilizing etc. The results in this study can be utilized to recommend suitable short-term crop for Hambantota and generally short-term crops having crop duration around 60 days would be preferable. Change of rainfall pattern and temperature would certainly effect the recharging of water system and so exploring ground water for irrigation.

T S G Peiris & J D J S Kularatne

5. EXTENSION ACTIVITIES

- Lectures were conducted for trainees attending courses organized by the Coconut Research Institute and National Institute of Plantation Management.
- Trainees from different Institutions were assigned to this Division from time to time.
- Visitors and students from Universities were briefed on the work of the Division.

6. CLIMATE IN CRI RESEARCH CENTERS

The four meteorological stations at Bandirippuwa Main Research Centre, Ratmalagara Research Centre, Ambakelle Genetic Resource Center and Maduru Oya Genetic Resource Centre were 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, 50, 100 and 200 cm depth. The rainfall, evaporation and sunshine duration were measured using rain gauge, class A evaporation tank and Campbell S 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.

6.1 Climate at Bandirippuwa Main Research Center

(a) **Rainfall:** The total rainfall for the year was 1723.6 mm (Table 9.1). This rainfall is much higher than the last year rainfall, but it is almost same as long-term (1994-2003) average. The months, January, February, March and April showed low rainfall compared to 2003, but the months from April to July showed high rainfall compared to 2003.

(b) **Temperature:** The monthly maximum temperature ranged from 30.9^{0}C (October) to 35.5^{0}C (March) while monthly minimum temperature ranged from 19.6^{0}C (December) to 23.5 (July) (Table 9.2). In general 2004 has higher maximum temperature and lower minimum temperature compared to long-term average resulting higher diurnal temperature in all months.

(c) **Sunshine:** Sunshine hours ranged from 5.4 (October) to 8.8 hrs/day (February). The average for the year was 7.0 hrs./day The year showed reduced sunshine hours compared to 2003 (Table 9.2).

(d) **Evaporation:** The lowest and highest evaporation was recorded in November and March with values 3.1 and 4.9 respectively (Table 9.2). The average for the year was 4.0 mm.

(e) **Relative Humidity:** The average relative humidity in the morning fluctuated around 82% during the year. In the afternoon it varied around 74% (Table 9.2).

6.2 Climate at Ratmalagara Research Center

Total rainfall during 2004 has increased by 26.6% compared to 2003 (Table 10.1), but the monthly distribution during the year is not normal. Rainfall during the first three months is 10.0 mm which is hardly insufficient for coconut. Rainfall during last quarter of the year (932 mm) has increased by 113% compared to 2003, but it may not beneficial to coconut due to excess of water.

The maximum temperature during January to April has significantly increased compared to long-term average (Table 10.2). The monthly distribution of other climate variables during the year was almost same compared to long-term monthly distribution.

6.3 Climate at Ambakelle Genetic Research Center

The rainfall in AGRC during 2004 has increased by 16.6% with respect to 2003 (Table 11.1). Not much rain has occurred during April as expected and as a results two peaks were during May and October/November. The rainfall during the first three months has dropped by 85% compared to the corresponding period in 2003.

According to Table 11.2 the first four months in 2004 showed high maximum temperature and minimum temperature. Minimum temperature was high during May and June. Monthly evaporation is generally low in AGRC throughout the year. Both RHam and RH pm are generally low during the first quarter of the year compared to long-term average. During the year both RHam and RHpm were highest during November.

6.4 Climate at Maduru Oya Seed Garden

Total rainfall recorded for the year was 1996.0 mm which is about 13% higher than rainfall during 2003 (Table 12.1) with respect to long-term average, it is about 25% higher. However there is 50% reduction during the first quarter of this year compared to 2003. During the last quarter of the year rainfall has increased by 67% compared to 2001.

Both maximum temperature and evaporation throughout the year was higher than the long-term average. Monthly minimum temperature was slightly lower than the long-term average. Highest sunshine duration was recorded during March, June and August and average duration in these months was 8.3 hours per day.

6.5 Climate at Poththukulama, Walpita and Pallama Research Centers

The monthly rainfall distribution for the year 2004 and long-term averages for the above three stations are shown in Tables 13, 14 and 15 respectively. The total rainfall during the year in all three stations is higher than the long-term average. The total rainfall during the year in Walpita and Pallama Research centers has increased compared to that in 2003, while the total rainfall during the year in Poththukulama Research center has decreased compared to that in 2003. With respect to rainfall during the first quarter of 2003, the percentage reduction during the first quarter of 2004 was 90% (Poththukulama), 62% (Walpita) and 47% (Pallama).

7. ACKNOWLEDGEMENTS

The assistance and co-operation of the staff of the Biometry Division, in conducting experiments, and surveys, analyzing data and maintaining the Local Area Network System and compiling this report are gratefully appreciated.

Table 9.1. *Monthly rainfall distribution at Bandirippuwa Main Research Center (in mm)*

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	94-03 Mean	2004
Jan	122.4	45.3	94.1	14.6	23.6	49.4	220.6	83.1	5.2	54.2	71.3	0.0
Feb	195.7	51.6	68.8	35.0	5.4	113.8	127.2	40.4	23.2	2.0	66.3	0.0
Mar	71.4	100.8	0.0	15.4	95.5	20.6	164.2	26.2	165.0	77.0	73.6	7.2
Apr	132.9	276.6	355.5	145.2	172.4	363.6	181.5	266.6	258.9	146.7	230.0	72.3
May	262.9	399.1	76.8	210.5	292.6	305.4	175.0	43.4	240.2	168.5	217.4	133.4
Jun	70.4	207.2	84.3	125.3	161.6	92.1	126.7	37.4	87.8	214.9	120.8	170.7
Jul	60.6	35.2	58.4	138.1	219.8	90.2	20.7	18.3	4.0	67.8	71.3	131.4
Aug	37.5	35.4	223.5	39.0	134.1	50.2	180.6	5.1	48.7	17.1	77.1	71.1
Sep	279.6	41.1	234.4	217.1	135.7	90.3	207.6	164.0	34.7	81.9	148.6	253.4
Oct	378.3	194.5	192.1	412.1	269.7	747.2	102.2	142.0	606.1	293.7	333.8	448.5
Nov	284.2	558.3	216.5	454.8	298.5	261.4	76.6	170.9	213.6	234.7	277.0	331.3
Dec	9.1	18.8	137.1	98.5	189.0	30.3	103.7	56.8	91.9	0.0	73.5	104.3
Total	1905.0	1963.9	1741.5	1905.6	1997.9	2214.5	1686.6	1054.2	1779.3	1358.5	1760.7	1723.6

Table 9.2. *Monthly distribution of other climate variables at Bandirippuwa Main Research Center*

Variable	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Tmax(C^0)	2004	33.5	33.8	35.5	34.1	32.7	32.7	31.6	30.3	31.3	30.9	31.2	31.8	32.5
	1994-2003	31.2	32.2	32.6	32.0	31.5	30.7	30.4	30.4	30.6	30.4	30.8	31.0	31.2
Tmin(C^0)	2004	21.2	20.6	21.7	22.9	22.4	22.4	23.5	23.2	21.4	21.8	20.1	19.6	21.7
	1994-2003	21.9	22.0	22.7	23.9	24.9	24.4	24.4	24.2	24.1	23.0	22.7	22.1	23.4
Sunshine(hrs)	2004	9.1	9.2	8.3	7.9	5.0	7.2	6.6	7.4	3.9	6.3	5.2	7.2	6.9
	1994-2003	7.3	8.4	8.4	7.6	7.3	6.6	6.9	7.4	6.7	6.2	5.9	7.2	7.2
Evaporation(mm)	2004	5.3	4.8	4.9	5.1	3.3	3.6	4.5	4.1	3.5	3.0	3.2	3.8	4.1
	1994-2003	4.1	4.4	4.6	4.2	3.8	3.7	3.8	3.9	3.8	3.2	3.2	3.8	3.9
RHam(%)	2004	82.0	77.0	78.0	79.0	82.0	83.0	83.0	83.0	83.0	84.0	85.0	83.0	81.8
	1994-2003	83.0	81.7	79.8	82.3	83.4	84.2	83.4	82.8	81.5	84.5	84.8	82.1	82.8
RHpm(%)	2004	67.0	74.0	69.0	70.0	74.0	82.0	79.0	78.0	78.0	78.0	82.0	75.0	75.5
	1994-2003	67.9	66.6	68.2	73.6	79.1	79.5	77.8	76.7	76.2	78.1	77.6	70.4	74.3

Table 10.1. *Monthly rainfall distribution at Ratmalagara Research Center (in mm)*

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	94-03 Mean	2004
Jan	101.5	16.6	41.1	0.0	28.8	79.1	89.7	116.2	12.4	112.2	59.8	0.0
Feb	63.4	55.7	104.8	4.8	4.0	42.9	231.5	46.1	25.1	27.8	60.6	6.2
Mar	21.0	85.6	0.7	14.8	70.2	3.1	111.6	0.0	80.9	177.8	56.6	4.0
Apr	218.2	287.3	133.2	81.7	151.6	185.9	243.1	231.6	330.0	125.8	198.8	159.9
May	281.8	257.9	54.5	177.8	198.2	291.7	157.5	112.8	159.7	138.3	183.0	207.3
Jun	64.5	121.0	93.1	73.3	92.4	83.8	108.2	25.0	73.8	264.3	99.9	109.4
Jul	55.9	19.9	31.8	143.1	79.0	47.1	10.3	5.7	4.8	48.0	44.6	90.0
Aug	22.1	17.3	91.0	13.2	111.3	18.4	177.3	10.3	9.6	5.4	47.6	46.2
Sep	132.7	13.5	238.2	219.8	104.0	99.8	157.1	187.6	54.7	26.5	123.4	198.5
Oct	545.8	148.1	204.9	486.2	338.7	769.2	107.7	243.4	445.5	251.9	354.1	301.5
Nov	204.4	584.3	164.5	670.1	348.9	367.8	120.0	301.9	456.3	168.7	338.7	528.5
Dec	6.4	22.5	41.5	190.5	223.4	56.9	185.7	50.5	147.6	16.6	94.2	101.7
Total	1717.7	1629.7	1199.3	2075.3	1750.5	2045.7	1699.7	1331.1	1800.4	1363.3	1661.3	1753.2

Table 10.2. *Monthly distribution of other climate variables at Rathmalagara Research Center*

Variable	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Tmax(C^0)	2004	34.2	35.4	35.1	34.4	31.3	30.8	30.4	31.4	31.3	31.5	31.4	30.9	32.3
	1994-2003	31.5	33.0	34.1	33.0	32.0	31.1	31.0	31.4	31.7	31.0	31.2	30.9	31.8
Tmin(C^0)	2004	21.0	20.6	22.8	23.8	24.2	24.4	24.2	24.0	23.6	23.5	22.6	21.2	23.0
	1994-2003	21.6	22.2	23.1	24.1	25.3	25.1	24.9	24.8	24.4	23.7	23.0	22.1	23.7
Sunshine(hrs)	2004	6.8	7.7	6.3	6.7	4.2	5.8	4.8	6.9	4.3	6.1	4.9	5.9	5.9
	1994-2003	5.4	6.1	6.6	6.2	5.7	5.1	5.1	5.6	5.7	5.1	5.2	5.2	5.6
Evaporation(mm)	2004	2.7	3.6	3.5	3.1	3.1	3.3	3.2	3.5	3.0	3.1	2.6	2.6	3.1
	1994-2003	3.1	3.5	3.9	3.6	3.3	3.1	3.3	3.4	3.2	2.9	2.6	2.8	3.2
RHam(%)	2004	84.5	82.8	80.8	85.6	82.7	81.0	81.5	82.5	85.0	87.5	89.1	88.7	84.3
	1994-2003	86.8	86.3	84.7	84.3	83.6	83.1	81.3	80.7	80.8	86.0	87.1	87.5	84.4
RHpm(%)	2004	53.9	50.7	54.4	62.2	75.8	76.3	75.5	70.4	73.2	72.0	76.8	71.8	67.8
	1994-2003	67.9	64.1	65.5	71.7	76.2	76.6	75.1	73.1	72.5	77.3	77.6	73.0	72.6

Table 11.1. *Monthly rainfall distribution at Ambakelle Genetic Resource Center (in mm)*

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	94-03 Mean	2004
Jan	110.5	51.2	127.7	0.0	41.3	35.0	102.5	90.5	9.5	46.1	61.4	0.0
Feb	71.6	32.6	91.2	3.6	18.3	196.4	79.5	63.2	84.0	19.6	66.0	25.8
Mar	79.6	59.5	0.0	2.5	118.8	0.0	183.8	0.0	23.6	161.3	62.9	11.5
Apr	141.4	348.2	105.0	101.7	89.7	131.0	258.8	262.6	406.8	178.6	202.4	56.8
May	184.3	337.7	7.4	179.3	259.1	205.4	164.6	15.8	162.4	71.0	158.7	319.2
Jun	85.5	81.1	133.6	70.3	35.8	32.9	72.7	46.6	70.8	162.0	79.1	93.1
Jul	39.4	27.7	10.4	97.1	85.4	22.1	1.4	2.9	0.0	94.9	38.1	84.9
Aug	4.9	13.8	66.6	7.0	23.8	18.5	157.6	7.1	10.1	14.5	32.4	11.4
Sep	115.9	2.7	159.1	256.3	127.2	129.3	164.8	134.3	71.3	23.5	118.4	128.0
Oct	274.6	178.2	263.4	387.9	229.3	540.2	64.9	137.7	453.3	217.4	274.7	229.1
Nov	165.5	666.5	139.7	448.6	317.1	251.7	65.8	171.2	220.5	199.6	264.6	340.3
Dec	12.8	34.9	90.9	213.2	304.2	74.4	185.2	32.7	132.0	22.3	110.3	110.9
Total	1286.0	1834.1	1195.0	1767.5	1650.0	1636.9	1501.6	964.6	1644.3	1210.8	1469.1	1411.0

Table 11.2. *Monthly distribution of other climate variables at Ambakelle Genetic Resource Center*

Variable	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Tmax(C^0)	2004	32.7	33.9	34.2	34.2	31.9	30.9	30.2	31.7	31.2	31.3	31.1	30.7	32.0
	1994-2003	31.0	32.4	33.7	33.3	32.7	31.5	31.4	31.8	32.1	31.3	31.2	30.9	31.9
Tmin(C^0)	2004	22.2	21.2	23.1	24.1	25.0	25.3	24.5	24.8	24.2	23.9	23.6	22.2	23.7
	1994-2003	21.5	21.9	22.8	24.0	25.1	25.2	25.0	25.0	24.5	23.7	23.0	22.5	23.7
Evaporation(mm)	2004	3.5	4.1	4.0	3.6	3.0	3.5	3.0	3.5	2.8	3.0	2.0	2.5	3.2
	1994-2003	2.9	3.4	3.9	3.6	3.3	3.3	3.6	3.9	3.6	4.1	4.9	3.6	3.7
RHam(%)	2004	83.0	73.8	71.0	75.9	81.9	79.7	82.5	75.9	79.6	79.0	84.8	81.7	79.1
	1994-2003	87.1	86.5	82.7	84.2	84.7	84.8	83.1	81.3	80.2	85.7	86.1	86.1	84.4
RHpm(%)	2004	60.5	53.3	59.4	62.4	76.3	73.5	75.3	68.8	71.8	74.5	77.3	74.9	69.0
	1994-2003	70.4	67.6	66.6	74.7	77.5	81.7	76.3	72.7	72.2	78.1	77.9	73.8	74.1

Table 12.1. *Monthly rainfall distribution at Maduru Oya Genetic Resource Center (in mm)*

Month	1995	1996	1997	1998	1999	2000	2001	2002	2003	95-03 Mean	2004
Jan	241.0	211.7	12.1	274.3	391.8	205.3	307.2	215.0	358.0	246.3	206.9
Feb	125.4	123.2	36.9	77.7	234.4	235.3	127.2	138.5	257.2	150.6	45.5
Mar	4.8	2.3	16.4	0.0	0.5	36.7	1.7	23.0	88.9	19.4	104.
Apr	162.7	122.7	211.6	39.3	19.1	34.1	242.4	175.2	63.7	119.0	41.7
May	48.7	3.9	121.6	133.2	0.0	19.6	0.0	11.2	82.3	46.7	60.5
Jun	6.9	71.8	23.0	3.1	13.8	22.1	49.0	5.9	26.2	24.6	0.0
Jul	11.2	0.0	20.9	84.6	0.0	27.9	59.0	0.0	64.0	29.7	38.7
Aug	69.9	162.8	1.7	201.2	31.5	79.7	0.0	8.2	27.1	64.7	35.0
Sep	248.3	9.3	109.7	44.4	128.3	57.6	50.9	74.1	0.0	80.3	123.0
Oct	82.2	149.5	329.5	29.9	300.4	24.0	201.0	197.5	114.7	158.7	382.4
Nov	147.4	334.7	327.4	243.7	294.7	506.5	280.5	279.0	521.9	326.2	416.8
Dec	175.6	240.6	311.6	548.9	247.6	257.6	463.1	529.5	156.9	325.7	541.4
Total	1324.1	1432.5	1522.4	1680.3	1662.1	1506.4	1782.0	1657.1	1760.9	1592.0	1996.0

Table 12.2. *Monthly distribution of other climatic variables at Maduru Oya Genetic Resource Center*

Variable	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Tmax(C^0)	2004	31.4	31.6	33.8	36.2	35.3	35.9	35.8	36.9	35.8	33	31.1	30.3	33.9
	1996-2003	30.2	31.5	34	34.6	35.1	34.8	34.8	34.9	35.3	33.7	31.5	30.5	33.4
Tmin(C^0)	2004	19.1	18.0	16.0	18.4	21.3	22.4	23.2	21.6	21.7	20.9	19.8	18.0	20.0
	1996-2003	21.4	21.2	21.5	23.2	23.3	23.8	23.5	23.3	22.8	22.5	22.5	22	22.6
Sun Shine(hrs)	2004	6.9	6.4	8.2	7.6	6.4	8.4	7.6	8.4	6.5	6.4	3.6	4.2	6.7
	1996-2003	5.6	6.3	8.8	7.4	7.6	7.2	7.8	7.8	7.5	6.3	5.4	4.5	6.9
Evaporation(mm)	2004	4.2	4.1	3.9	4.4	4.4	5.5	4.8	5.2	4.4	4.7	3.5	3.6	4.4
	1996-2003	3	3.2	4.1	3.6	4.8	5.2	5.7	5.4	5.3	4.9	3.3	3.8	4.4
RHam(%)	2004	76.5	78.9	73.9	75	62	49.4	51.3	48.9	51.2	66.5	77.7	73.4	65.4
	1996-2003	74.9	69.6	60.1	57.4	60.3	60.8	57.3	59.9	58.6	64.3	73.5	76.7	64.5
RHpm(%)	2004	84.1	86.3	83.1	76.5	72.4	61.4	67.3	63.5	74.3	78.5	86.2	85.6	76.6
	1996-2003	90.3	89.8	86.9	70.5	74.2	73.1	69.1	68.5	68.7	76.5	85	88.6	78.4

Table 13. *Monthly rainfall distribution at Poththukulama Research Center (in mm)*

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	94-03 Mean	2004
Jan	115.6	91.0	54.5	0.0	37.3	22.8	73.3	82.3	0.0	44.0	43.4	0.0
Feb	48.6	16.8	72.7	0.0	25.0	117.0	43.4	61.4	56.4	23.0	38.7	24.0
Mar	27.8	12.5	0.0	0.0	109.3	0.0	194.3	0.0	20.0	338.6	58.5	21.6
Apr	112.1	323.8	142.2	87.7	95.7	130.9	164.9	297.8	460.4	214.6	169.2	77.4
May	120.2	449.5	0.0	144.2	205.3	213.8	20.3	8.6	137.1	55.4	112.9	198.0
Jun	44.4	88.4	118.8	46.6	30.5	34.2	65.4	37.0	54.6	146.8	55.6	99.8
Jul	15.2	0.0	13.9	51.3	104.1	20.0	0.0	2.5	0.0	57.0	22.0	95.7
Aug	0.0	6.3	88.8	0.0	35.0	8.8	188.8	0.0	10.0	7.0	28.7	12.6
Sep	94.4	0.0	190.2	200.4	79.5	80.2	139.1	162.0	20.2	24.0	82.5	77.0
Oct	391.3	116.8	257.7	168.4	230.8	442.8	163.5	111.6	405.7	178.4	205.6	199.3
Nov	161.4	494.5	199.9	399.0	186.4	173.5	51.8	167.2	283.5	251.5	197.4	417.3
Dec	6.3	36.2	62.1	177.4	213.9	70.7	160.8	79.8	144.0	23.0	81.2	116.6
Total	1137.3	1635.8	1200.8	1275.0	1352.8	1314.7	1265.6	1010.2	1591.9	1363.3	1095.6	1339.3

Table 14. *Monthly rainfall distribution at Walpita Research Center (in mm)*

Month	1998	1999	2000	2001	2002	2003	98-03 Mean	2004
Jan	38.4	79.9	247.6	116.7	23.0	164.0	111.6	0.0
Feb	0.0	120.6	238.3	91.8	31.6	21.0	86.6	45.0
Mar	47.4	14.7	104.2	0.0	109.8	265.2	90.2	126.3
Apr	148.9	360.4	145.0	447.0	514.8	284.2	316.7	156.9
May	280.3	524.2	206.9	193.0	275.1	140.5	235.5	284.4
Jun	213.3	126.3	130.0	84.4	216.2	251.0	170.2	184.1
Jul	145.6	101.3	52.6	36.4	17.8	251.2	100.8	196.0
Aug	206.9	104.9	332.0	11.2	57.5	142.8	142.6	81.5
Sep	288.6	127.2	447.6	289.3	84.5	75.0	218.7	419.9
Oct	332.0	823.8	141.2	155.6	519.0	382.0	392.3	410.0
Nov	350.8	433.2	163.5	208.5	276.3	240.5	278.8	360.3
Dec	189.7	36.4	87.2	84.2	83.2	0.0	80.1	135.8
Total	2241.9	2868.9	2089.2	1718.1	2208.8	2217.4	2224.1	2400.2

Table 15. *Monthly rainfall distribution at Pallama Research Center (in mm)*

Month	2001	2002	2003	01-03 Mean	2004
Jan	94.0	5.0	38.4	45.8	0.0
Feb	35.0	28.0	20.1	27.7	72.0
Mar	0.0	30.5	189.9	73.5	6.0
Apr	310.5	497.0	215.3	340.9	138.4
May	17.5	129.0	114.6	87.0	276.5
Jun	38.0	45.0	187.0	90.0	109.5
Jul	5.0	0.0	49.6	18.2	93.6
Aug	7.0	0.0	48.6	18.5	10.9
Sep	175.0	34.0	10.0	73.0	66.0
Oct	154.0	291.8	223.7	223.2	208.8
Nov	188.0	264.0	206.3	219.4	326.9
Dec	80.0	141.3	22.2	81.2	138.6
Total	1104.0	1465.6	1325.7	1298.4	1447.2

REPORT OF THE TISSUE CULTURE DIVISION
Head - L K Weerakoon, Ph D

1. GENERAL

During the year, much emphasis was placed on the germplasm exchange programme. Embryos of 10 coconut varieties namely, Polynesia Tall, Tagnanan Tall, Vanuatu Tall, Tacunan Green Dwarf, Tahitian Tall, Niuleka Green Dwarf, Tenga Tall, Malayan Red Dwarf, West African Tall and Catigan Green Dwarf were brought from Ivory Coast in September. These embryos were cultured and maintained under *in vitro* conditions. One hundred and four plants raised from embryos (of 4 coconut varieties) brought from India were fully acclimatized and ready for field planting. The germination of embryos brought from PNG was found to be very poor and thus the recovery rate was very low.

A total of 217 Dikiri embryos were cultured during the year and 118 *in vitro*-raised plants were successfully acclimatized. Over 30 embryo-cultured Dikiri plants were distributed among growers.

The growth and physiological parameters of the palms (that survived the stress conditions caused by different concentrations of PEG) that had been established at Lenawa Estate were measured.

Five tissue-cultured coconut plants were established at Bandirippuwa Estate to evaluate their performance in the field and 9 more plants are ready for field planting. The growth of the tissue-cultured plants established previously at Bandirippuwa Estate, Lenawa Estate, Daisy Valley Estate and Pallama Seed Garden was found to be satisfactory and three of them came in to bearing during the year. No abnormalities in vegetative growth or nut characters were observed in these palms.

Formation of callus in heat-pretreated anthers obtained from inflorescence of 3 WBS (3 weeks before splitting) stage was observed. This was the first time that callus formation in coconut anthers was reported. However, the ploidy level of the callus formed need to be tested to determine whether they are of haploid origin. It was possible to induce callusing in ovule explants excised from female flowers contained within inflorescences of -1 and -2 maturity stages (taking the youngest open flower as 0). However, flowcytometric analysis revealed that the calli are diploid.

The attempts to induce secondary embryogenesis in immature embryo and plumule- derived callus were continued. Callogenesis in plumule and immature inflorescence explants could be enhanced by application of epibrassinolide, a novel plant growth regulator.

Analysis of sugar profiles of inflorescence tissues of different maturity stages was undertaken to generate more information on biochemical markers. The results revealed a higher accumulation of sucrose in –6 to –8 stages that might have some significance in morphogenesis.

Preliminary investigations on cryopreservation of coconut plumules were undertaken and different pre-treatments on encapsulated coconut plumules are being tested to develop effective cryopreservation techniques.

Investigations on embryo culture of "Kitul" (*Caryota urens*) were initiated and the preliminary results indicated the possibility of using modified Eeuwens Y3 medium (the medium that is used for embryo culture of coconut) for *in vitro* germination and growth of "Kitul" embryos.

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 217 Dikiri embryos were cultured during the year and 118 *in vitro*-raised plants were successfully acclimatized. Over 30 embryo-cultured Dikiri plants were distributed among growers.

L K Weerakoon, T R Gunathilake, K P I E Ambagala & E S Santha

Experiment 18.1.2: Screening coconut germplasm for drought-tolerance using *in vitro* techniques (1986)

The growth and physiological parameters of the palms (that survived the stress conditions caused by different concentrations of PEG) established at Lenawa Estate were measured.

L K Weerakoon, C S Ranasinghe, K P I E Ambagala, R Silva, N Premasiri, P A S de Sarem & E S Santha

Experiment 18.1.6: Cryopreservation of coconut embryos and plumules

In collaboration with IRD, France, preliminary investigations on cryopreservation of coconut plumules were initiated. Cryopreservation of coconut plumules through encapsulation/dehydration method was tested. The plumules were excised from mature zygotic embryos of Sri Lanka Tall coconut and encapsulated in sodium alginate. The beads were subjected to different pretreatments comprising of 0.75 M sucrose alone and in combination with 3 different concentrations of ABA (10, 20 and 40 μM) to test the cryoprotectant ability. Prior to freezing in liquid nitrogen, the plumules were subjected to further desiccation by exposure to silica gel for 16 h. Histological analysis was also undertaken to measure the degree of cell damage caused by different treatments. The water loss from plumules during pretreatment and desiccation was monitored and survival and recovery of plumules after each treatment was studied.

The results clearly indicated the positive effect of ABA on survival and recovery of both unfrozen and frozen plumules. A very high survival rate (92 and 91%) was observed in unfrozen plumules pretreated with 20 and 40 μM ABA respectively. Similarly, pretreatment with ABA increased the survival rate of frozen plumules and the highest survival (88%) was observed in the plumules pretreated with 40 μM ABA. The recovery of plumules (frozen and unfrozen) pretreated only with sucrose was found to be very low whereas a remarkable improvement in recovery was observed with ABA. In frozen plumules, the highest rate of recovery (35%) was achieved when pretreated with 20 μM ABA. The lowest percentage of water loss (61.5%) was recorded in the plumules pretreated with 0.75M sucrose alone whereas the water loss was highest (69%) for plumules pretreated in 0.75M sucrose in combination with 40 μM ABA.

Histological analysis revealed that extensive cell damage has taken place in frozen plumules that did not undergo any pretreatment or desiccation. In ABA-treated, cryopreserved plumules, the extent of cell damage was minimal and most of the cells in the apical region were intact. Thus the higher rate of post-thaw recovery in plumules pretreated with ABA was confirmed by histological studies, indicating that ABA in combination with sucrose is an effective cryoprotectant agent for cryopreservation of coconut plumules.

Experiment 18.1.7: Exchange of coconut germplasm through embryo culture

One hundred and thirteen plants raised from embryos (of 4 coconut varieties) brought from India were fully acclimatized and ready for field planting (Table 1).

Table 1. *Performance of coconut embryos collected from India*

Name of the Cultivar	Number of embryo cultures successfully initiated	Number of embryos germinated	Number of in vitro plants transferred to soil	Number of plants still at hardening stage	Number of plants ready for field planting
Andaman Ordinary	175	137	84 (27)*	10	49
Laccadive Ordinary	191	100	37 (22)*	02	19
Indian West Coast Tall	182	106	58 (22)*	06	34
Banawali Green Round	121	68	35 (20)*	01	11

* No. given in parenthesis indicate weak or contaminated plants out of the total number

The germination of embryos (of 10 different varieties) brought from Papua New Guinea (PNG) was found to be very poor and thus the recovery rate was very low. The ungerminated embryos were subcultured several times in GA_3 containing media to induce germination. Since most of the embryos did not respond to this treatment, the shoot tips were excised and cultured in solid Y3 medium (in the case of fairly enlarged embryos, a sizable portion of the embryo containing both shoot and root poles was excised), as a last resort. This was the first time such an attempt was made with *in vitro*-cultured embryos. However, there were many embryos that did not show any growth (no enlargement) and with these embryos, it was not possible to excise the shoot tips and they had to be discarded. However, the growth of the shoot tip cultures was very poor. One reason for this may be that the excision of shoot tips was done at a very late stage (after several months in culture) and thus the material was not fresh. However, some shoot tips developed well and gave rise to complete plants.

Even after germination, many embryos did not grow well in culture and these did not develop in to complete plants that could be transferred to soil. Intense browning and premature senescence of embryos was observed in some cultures. Even some of the well developed plants could not be rescued as a result of quick browning of leaves. Out of the plants transferred to soil, some were very weak and thus they did not survive during acclimatization.

Forty seven plants obtained from PNG material were fully acclimatized and ready for field planting whereas over 70 plants are still at different stages of acclimatization.

Embryos of 10 coconut varieties namely, Polynesia Tall, Tagnanan Tall, Vanuatu Tall, Tacunan Green Dwarf, Tahitian Tall, Niuleka Green Dwarf, Tenga Tall, Malayan Red Dwarf, West African Tall and Catigan Green Dwarf were brought from Ivory Coast in September of 2004. Even in the case of Ivory Coast material, germination was very poor. Thus excision of shoot tips was done at an early stage and some of these cultures show good growth. However, there were many embryos that did not enlarge. Thus the plumules of these embryos were dissected under a stereo microscope and cultured in the growth medium. However, none of these plumules showed any sign of growth even after several weeks in culture.

L K Weerakoon, S C Fernando, K P I E Ambagala, E S Santha, T R Gunathilake, J M D T Everard, L Perera & C Bandaranayake

18.2. Studies on clonal propagation of coconut

Experiment 18. 2. 1: *In vitro* culture of immature zygotic embryos of coconut

A general decrease in the frequency of callusing and somatic embryogenesis in immature embryo explants was observed. Investigations are underway to find out possible reasons for this effect. The attempts to induce secondary embryogenesis in immature embryo-derived callus were unsuccessful. Five clonal plants derived from immature embryo callus were planted in the field.

L K Weerakoon, S C Fernando, E S Santha & K P I E Ambagala

Experiment 18. 2. 4: Culture of floral meristem explants (1995)

Studies on biochemical markers were continued to find any correlation between the biochemical characteristics of immature inflorescence explants and their morphogenic potential. Analysis of total sugar content and sugar profiles of inflorescence tissues of different maturity stages (–5 to –9 stages; considering the youngest open inflorescence as 0 and the inflorescence that is to be opened next as -1) was undertaken to generate more information on biochemical markers.
The results revealed a higher accumulation of sugars in –6 to –8 stages (Table 2) that may have some significance in morphogenesis, especially as an energy source. Regarding callusing frequency, the 10 cm length inflorescence that responds best for callusing usually falls within this range.

Table 2. *Variation in the concentration of sugars in inflorescence tissues at different stages of maturity*

Sugar content	Maturity stage of Inflorescence				
	-5	-6	-7	-8	-9
Total sugar µg/g DW	149272.56	172251.23	189808.77	149922.60	126278.44
Sucrose µg/g DW	97424.45	135683.33	136419.56	116262.94	96246.45
Fructose µg/g DW	15836.53	20577.03	30811.80	30186.05	24648.54
Raffinose µg/g DW	5394.86	5865.95	5409.39	5321.52	-
Glucose µg/g DW	4642.49	5975.34	5869.76	12102.32	-

Histological analysis also revealed that inflorescence tissues of the above maturity stages contain cells with high meristematic activity. Thus the high content of sugars and the presence of meristematically active cells in the -6 to –8 stages probably indicate the high morphogenic potential of these explants.

Callogenesis in immature inflorescence explants could be enhanced by application of epibrassinolide, a novel plant growth regulator.

H D D Bandupriya, L K Weerakoon, C S Ranasinghe & K Fernando

Experiment 18. 2. 5. Culture of plumule explants (1997)

Callogenesis in plumule explants could be enhanced by application of epibrassinolide but the frequency of somatic embryogenesis was found to be low.

S C Fernando

Experiment 18. 2. 7. Studies on coconut anther, unfertilized ovary and ovule culture (1997)

Selection of explants at the correct maturity stage for *in vitro* culture is difficult, without a thorough knowledge on the events that take place during inflorescence development. However, very little information is available on the developmental process of coconut inflorescence. Therefore, a detailed histological study on inflorescence development was undertaken.

A series of Inflorescences from –1 to –26 maturity stages (considering the youngest open inflorescence as 0, the most mature stage is -1 whereas the most immature stage is –26) were collected for histological analysis.

Development of an inflorescence in coconut is a very long process. There are several activities taking place in the total developmental process, namely, primary bract formation, rachilla formation, secondary bract formation, pistillate and staminate floral bud formation, sexualisation and sporogenesis. The study revealed that this developmental process comprises of a series of individual events (Table 3). The findings of the study were very useful in selecting suitable explants (at the correct developmental stage) for *in vitro* culture.

The findings of the study were very useful in selecting suitable explants (at the correct developmental stage) for *in vitro* culture.

Table 3. *Sequence of events that take place during the development of a coconut inflorescence*

Maturity Stage of inflorescence	Description of the developmental events
-26	Inflorescence initiation could be identified with actively dividing cells at the base of the subtending leaf
-25	Development of external spathe.
-24	Completion of the differentiation of external and internal spathes
-23	Further elongation of the inflorescence
-22	Differentiation of primary bracts
-21 to -19	Initiation of new primary bracts and elongation of the differentiated old bracts.
-18	Production of more bracts
-17	Initiation of rachillae
-16	Initiation of new rachillae and elongation of differentiated rachillae
-15	Initiation of secondary bracts
-14	Elongation of secondary bracts and initiation of pistillate flower buds at the basal part of the rachilla
-13	Increase in the mass of active cells of pistillate flowers Initiation of staminate flowers
-12 to -10	Increase in the size of active cell masses in both pistillate and staminate flowers and differentiation of new staminate flowers
-9 to -8	Differentiation of sepals in both pistillate and staminate flowers
-7	Differentiation of petals in both pistillate and staminate flowers
-6	Differentiation of pistil and stamens in both pistillate and staminate flowers
-5	Presence of actively developing stamen and pistil in both pistillate and staminate flowers
-4	Differentiation of ovary into ovule and carpels; termination of the activity of stamen, resulting in a rudimentary stamen in pistillate flower Differentiation of stamen into filament and anther; termination of the activity of pistil resulting in a rudimentary ovary in staminate flower
-3	Differentiation of ovule Formation of pollen sac in the anther
-2	Differentiation of ovule into integuments and embryo sac Formation of pollen mother cells in the pollen sac
-1	Development of megaspore in ovule Development of microspores in pollen sac
0	Formation of fully matured pistillate flower Formation of fully matured staminate flower

Two different culture media [medium 72 and Eeuwens Y_3 medium supplemented with 100 µM 2, 4-D and 0.1 % activated charcoal) were tested for callus induction in explants of four different maturity stages (ovaries at stages -4 and -3 and ovules at stages -2 and -1). As shown in Table 4, unfertilised ovary as well as ovules produced callus in both the culture media tested.

The calli were subcultured into somatic embryo-induction medium, containing 5 µM abscisic acid (ABA) and 10 µM $AgNO_3$, followed by somatic embryo maturation medium (without hormones) and germination medium (modified Eeuwens Y_3 medium). The callus, subcultured on medium containing ABA produced somatic embryos at a frequency of about 50%. About 10% of germinating shoots could be observed in plant regeneration medium.

Histological studies revealed that the female flowers at stage -4 contained active meristematic cells that will give rise to the ovule. The initial stage of callogenesis in ovary explants was indicated

by the formation of new meristematic cells originated from provascular cells of the carpel. Further cell division towards the epidermis of the carpel resulted in the formation of a highly meristematic region, referred to as the cambium-like zone (CLZ). Periclinal cell division of the peripheral cells of the CLZ and the anticlinal cell division of the inner parenchyma cells ensured the growth of the callus.

Histological analysis also revealed that coconut somatic embryos from ovary explants could be formed either by a uni-cellular or a multicellular pathway. In the multicellular pathway, the first stage of development of embryogenic nodules was indicated by the fragmentation of the CLZ and these nodular structures developed further and formed proembryos of multicellular origin. These proembryos developed to give rise to fully-developed somatic embryos later. Most of the somatic embryos analysed were bipolar with well defined shoot and root poles. In the unicellular pathway, some highly embryogenic cells present in the protoderm (the periphery of the CLZ) give rise to proembryos. A proembryo is produced as a result of mitotic divisions within an isolated, single embryogenic cell. However, further development of these proembryos was not observed.

Table 4. *The percentage of callus production in ovary and ovule explants in 2 different culture media*

Maturity stage of explant	Percentage callus production	
	Medium 72	Eeuwens Y_3 medium
-4	14	14
-3	43	52
-2	20	22
-1	33	23

After subculturing the somatic embryos into the germination medium, further differentiation of shoot meristem and haustorial tissues occurred. Initially, the shoot meristem consisted of a mass of meristematic cells which later differentiated into the meristematic dome, spear leaves, pith and provascular bundles. Most of the shoots analyzed were normal with the meristematic dome covered by several leaf sheaths. However, some fused shoots and multiple shoots were also observed.

Flow cytometric analysis revealed that all the calli tested (initiated from ovary and ovule explants) were diploid. It indicated that the origin of the calli is either from carpels or diploid cells of the ovule.

Ovary-derived calli and embryogenic structures were used for in-situ hybridisation to study the expression of a cell cycle controlling gene called Retinoblastoma (*Rb* gene). Results revealed that the expression of *Rb* gene is high in developing calli and shoot meristem whereas its expression was low in incomplete somatic embryos and leafy structures.

Anthers collected from inflorescences at 3 Weeks Before Splitting stage were used as explants to test the effect of cold (4 °C) and heat (38 °C) pre-treatments (for different durations) on callogenesis. Callus production at a low frequency was observed in heat pre-treated anthers (5 and 7 days). This was the first time that callus production from coconut anthers was reported. Analysis of ploidy level using flow cytometry indicated that the callus is of haploid origin.

P I P Perera, L K Weerakoon & S C Fernando

Experiment 18. 2. 14. Micropropagation of high-value crops (2002)

Investigations on embryo culture of "Kitul" (*Caryota urens*) were initiated. The standard growth medium used for embryo culture of coconut (modified Eeuwens Y3 medium) was tested for *in vitro* germination and growth of "Kitul" embryos. The preliminary results indicated that solid Y3

medium is better for germination of embryos when compared to liquid Y3 medium. Upon germination, the embryos were transferred to liquid Y3 medium for further growth. A few of the plants with good shoot and root growth were transferred to soil for acclimatization.

L K Weerakoon & E S Santha

18.2.16 Field establishment of clonal coconut plants (1999)

Seventy seven tissue-cultured coconut plants have been established at 4 different locations (Table 5). Three of the palms derived from shoot tip callus (Variety: Sri Lanka Green Dwarf X Sri Lanka Tall) have come to bearing. No abnormalities in vegetative growth, floral development and nut characters were observed in these palms. Microsatellite markers were used for testing genetic fidelity of these plants. Thirty-one tissue-cultured coconut plants of 7 clones were analyzed and no variations were observed within a single clone.

Table 5. *Field establishment of tissue-cultured coconut plants*

Location	Original explant	Number of plants
Bandirippuwa Estate	Immature embryo Plumule Shoot tip Tender leaf Immature inflorescence	24 07 08 02 01
Daisey Valley Estate (Mawathagama)	Immature embryo Plumule	10 02
Lenawa Estate	Immature embryo Plumule	06 04
Pallama Seed Garden	Immature embryo Plumule	10 03
	Total	77

S C Fernando, L K Weerakoon, H D D Bandupriya, K P I E Ambagala, E S Santha & T R Gunathilake

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REPORT OF THE COCONUT PROCESSING RESEARCH DIVISION
Officer – in –Charge – J M N Marikkar

1. GENERAL

The research program of the Coconut Processing Research Division during the year 2004, has given more emphasis on developing kernel based products, value added oil based products as well as fermentation products.

Trials were carried out to expel virgin coconut oil and to produce value added virgin coconut oil products. It was found that analytical parameters of virgin coconut oil are within the SLS specifications even after 2 years of storage at ambient conditions. Different treatments were used for the formulation of a salad dressing. Sample treated with 0.01 % tocopherol and 0.13 % sodium metabisulphite was found to be the most acceptable formulation in terms of sensory attributes and chemical composition. Apart from these, fractional crystallization studies were also undertaken to produce coconut oil fractions enriched with medium chain fatty acids.

Coconut kernel contains a lot of fiber. Therefore, coconut kernel residue (after extracting coconut milk) can be a good source of dietary fiber. An attempt was made to develop fiber enriched noodles by incorporating coconut kernel residue into wheat flour. It was found that noodles prepared with 20% coconut flour substitution were acceptable. Similarly, an instant 'thosai sambol' was prepared using defatted coconut flour obtained as a by-product in the virgin coconut oil production.

Coconut paste technology was introduced by the division as an alternative method for traditional coconut milk extraction. Further value addition to coconut paste was also undertaken. Instant curry paste is one of the convenient products demanded by the modern society. Therefore, an experiment was carried out to develop an instant chicken curry paste, which would be acceptable to consumers. It was found that the product is microbiologically safe and has a shelf life of at least six months.

A coconut skim milk beverage concentrate was prepared with different treatments. Sample treated with 1 % CMC, 0.035 % Sodium metabisulphite and 0.5 % flavour was found to be the most acceptable in terms of sensory attributes and chemical composition. Under ambient temperature (30±2 °C), the product was stable for a period of 4 months. Further trials are being continued to improve the shelf life and the acceptability of the product.

Coconut water released by the copra and desiccated coconut manufacture has become a source of pollution. Therefore, studies were undertaken to develop products using seasoned nut water. It was found that artificially flavored sports drink is much acceptable compared with both naturally flavored sports drink and commercial sports drinks. Further studies are being carried out to improve their quality parameters. Apart from this, a low cost vinegar making technology was developed using seasoned coconut water. The product was evaluated for physico-chemical and sensory properties. Results showed that coconut water can be processed into vinegar by allowing sweetened coconut water to alcoholic and acetic fermentation by the addition of 10% mother vinegar.

Experiment 01: Fractional crystallization of coconut oil

Medium chain fatty acids (MCFA) are highly regarded for their nutritional value. In Sri Lanka, coconut oil contains more than 60% of MCFA. It is proposed that fractional crystallization of coconut oil can be used to get MCFA enriched fractions. Therefore, a study was attempted to investigate multi-step crystallization (dry process) as a method to isolate MCFA enriched fraction. Under this method, coconut oil was subjected to a cooling program which yielded six different fractions (DF-1, DF-2....DF-6). The crystallization steps, yield of each fraction, and physico-chemical data are shown in Table 01.

Table 01. *Multi-step crystallization of coconut oil by dry process**

Fractions	Crystallization Temperature (°C)	Crystallization Time (Min)	Yield (%)	Iodine value	SMP (°C)
Control	-	-	100.0	10.1	25.6
DF-1	24	250	5.5	8.2	25.5
DF-2	23	180	2.9	8.5	25.3
DF-3	22	120	10.9	8.6	25.5
DF-4	21	35	5.9	9.0	25.3
DF-5	20	6	16.3	8.7	25.5
DF-6	<20	-	53.9	9.6	25.3

*Abbreviations: DF, dry fractions of series; SMP, slip melting point

MCFA distribution pattern of the fractions isolated from crystallization were examined by the fatty acid profile data obtained using gas liquid chromatography (GLC). Based on the data in Table 02, fraction DF-1 was found to have the highest proportion of MCFA, which was 7.95% higher than that of the control. Subsequently, the cooling process was repeated using fresh coconut samples to isolate more and more of DF-1 fraction in order to use it in product development work.

Table 02. *Percent distribution of MCFA in coconut oil and its fractions**

Sample	MCFA (%)
Coconut oil	65.15
DF-1	73.10
DF-2	68.95
DF-3	57.55
DF-4	45.05
DF-5	47.70
DF-6	46.60

*Abbreviation: MCFA, Medium chain fatty acids; DF, dry fraction of series.

J. M. N. Marikkar & W. C. K. Jayasuriya

Experiment 02: Development of medium chain fatty acid enriched-biscuits using coconut oil fraction as the fat component

Biscuit is popularly consumed as a snack food by children as well as adults. Biscuit essentially carry a fat component, which is usually a commercial shortening. The commercially available shortenings are mostly prepared out of palm oil or other hydrogenated vegetable oils. Due to this reason, shortening are found to contain a higher proportion of longer chain fatty acids such as palmitic ($C_{16:0}$), stearic ($C_{18:0}$), oliec ($C_{18:1}$), and linoleic ($C_{18:2}$) acids. Alternatively, coconut oil has a high content of short and medium chain fatty acids such as caproic ($C_{6:0}$), caprylic ($C_{8:0}$), capric ($C_{10:0}$), and lauric ($C_{12:0}$) acids. Since these fatty acids are highly regarded as quick energy providers, coconut oil can be used as fat component in biscuit in place of commercial shortenings.

In this experiment, three different kinds of biscuit samples namely, BSS, BSC and BSF were prepared using wheat flour as the major ingredient. The fat component used in BSS, BSC and BSF samples were commercial shortening, pure coconut oil, and first fraction of coconut oil (DF-1:

obtained from fractional crystallization experiment), respectively. The results obtained for proximate composition and sensory evaluation of these biscuit samples are presented in Tables 03 and 04, respectively.

Table 03. *Proximate composition of biscuit samples*

Samples	Moisture	Lipid	Protein	Carbohydrate	Ash
	(%, w / w)				
BSS	4.80±0.20	19.07±0.52	13.00±0.05	61.33±0.23	1.80±0.20
BSC	3.45±0.31	22.97±0.36	13.52±1.83	58.66±0.39	1.41±0.31
BSF	4.77±0.10	23.01±0.83	13.10±1.17	57.46±0.87	1.75±0.10

Abbreviations: BSC, biscuit sample from coconut oil; BSF, biscuit sample from first fraction; BSS, biscuit sample from shortening; Each value in the table represents the mean ± standard deviations of duplicated analysis.

Table 04. *Evaluation of sensory attributes of biscuit samples*

Sample	Appearance		Flavour		Mouth feel		Odour		Overall acceptability	
	E.M	S.R	E.M	S.R	E.M	S.R	E.M	S.R	E.M	S.R
BSC	5.3	63.0	5.7	74.5	5.0	68.5	5.3	65.0	6.0	72.0
BSF	5.7	74.0	5.0	60.5	5.0	64.5	6.0	73.0	6.0	72.5
BSS	5.0	61.0	5.3	63.0	5.0	65.0	4.7	59.5	5.0	53.5
Grand median	5.33		5.33		5.00		5.33		5.67	
Probability	0.15		0.19		0.84		0.20		0.02	

Abbreviations: E.M, estimated median; S.R, sum of ranks; BSC, biscuit sample from coconut; BSF, biscuit sample from first fraction; BSS, biscuit from shortening.

According to Table 04, there were no significant difference ($p>0.05$) among the three samples with respect to appearance, flavour, mouth-feel and odour. However, BSF sample scored higher sum of ranks for appearance and odour than other two samples. The data further showed that there was significant difference among the sample with regard to the overall acceptability. In this, the panelists gave the highest sum of ranks for the BSF sample followed by BSC and BSS samples.

In order to estimate MCFA distribution among the biscuit sample, fat component of the samples were analyzed by GLC. According to Table 05, the highest amount of MCFA was found in BSF. The amount of MCFA found in BSF was about 2% higher than that of the BSC. Since BSS sample was prepared out of commercial shortening, it was found to contain the lowest amount of MCFA. In conclusion, the contribution of MCFA in biscuit by coconut oil and its fraction was almost double compared to that of the commercial shortening.

Table 05. *Percentage of medium chain fatty acids of biscuit samples*

Sample	MCFA (%)
BSS	20.48
BSC	45.89
BSF	47.93

Abbreviations: MCFA, Medium chain fatty acids in percentage; BSC, biscuit sample from coconut oil; BSF, biscuit sample from first fraction; BSS, biscuit sample from shortening.

J. M. N. Marikkar & J. G. M. T. Udayakumara

Experiment 03: Formulation of a salad dressing out of virgin coconut oil

Three different salad dressing recipes were developed and sensory evaluation was done to find out the best recipe used for preparation of salad dressing. Virgin coconut oil 750g was taken and it was homogenized at 12,000 rpm 5 ±2 ^{0}C for 5 minutes by using an ULTRA-TURRAX (T25 basic IKA). Whole egg was whipped with water and vinegar. Finally sugar, salt, pepper, defatted coconut powder and mustard were added into the mixture.The entire mixture was homogenized at 12,000 rpm at 5 ±2 ^{0}C for 5 minutes and citric acid was added until the pH value of the homogenized mixture was adjusted to 3.0. The mixture was poured into sterilized glass bottles and stored under refrigerated condition. Quantities of ingredients needed to prepare twelve 130 ml glass bottles are shown in Table 06.

Table 06. *Quantities of ingredients*

Ingredients	Quantity (g)
1. Coconut oil	750-800
2. Whole egg	80
3. Salt	15
4. Mustard	2
5. Vinegar	132
6. Water	12
7. Sugar	10-8
8. Defatted coconut powder	10
9. Lime Juice	10
10. White pepper	10
11. Citric acid	1

Preparation of three different recipes

Fermented salad dressing recipe (S1) was developed by using yoghurt culture with general ingredients. It was allowed for ferment at 42 ^{0}C for 5 hours. Sweet salad dressing recipe (S2) was developed by using high amount of sugar with general ingredients. High amount of vinegar and citric acid with general ingredients were used to develop sour salad dressing recipe (S3).

Selection of the most acceptable recipe

The three processed salad dressings were evaluated for sensory attributes such as of colour, taste, smell and overall acceptability by using 30 semi-trained panelists. For the evaluation, 5 point modified Hedonic scale was used as follows.

Like very much	5
Like moderately	4
Neither like nor dislike	3
Dislike moderately	2
Dislike very much	1

Selection of the most acceptable treatment

The most accepted salad dressing recipe was selected and prepared in bulk. The entire salad dressing was subjected to different treatments (T1, T2, T3 and T4)

T1 –Treated with 0.01 % antioxidant
T2- Treated with 0.13 % preservative
T3- Treated with 0.01 % antioxidant and 0.13 % preservative
T4- Not treated.

Sensory attributes such as colour, taste, smell and overall acceptability of four treated salad dressings were evaluated using semi-trained panelists. The samples were stored at 5±2 ^{0}C.

Comparison with market available salad dressing

The most acceptable salad dressing recipe was compared with randomly selected market available salad dressing. The salad dressing was evaluated for colour, taste, smell, and overall acceptability by using 30 semi-trained panelists. The results of sensory evaluations were analyzed using Kruskal Wallis test and Statistical Analysis System (SAS) statistical package.

Chemical analysis of formulated salad dressing and market available salad dressing

Proximate composition of formulated salad dressing and market available salad dressing was analyzed for crude protein, total sugar, crude fat, peroxide value, free fatty acid content, moisture content, ash content and fatty acid profile.

Shelf-life studies

Shelf-life studies were done every four weeks for four months. Peroxide value and free fatty acid content were estimated. Total plate count was recorded as a measure of microbial parameter.

Based on the results, the taste, smell and overall acceptability were significantly different (probability value 0.05) among the three recipes (S1, S2, S3)(table07). However colour, was not significantly different among the three recipes. Similar mean scores (3.16) were obtained for colour in all the three salad dressings. Sweet salad dressing (S2) showed higher mean scores than those of S1 and S3 for taste, smell and overall acceptability (4.83, 4.16 and 4.76 respectively). With respect to sensory attributes of taste, smell and overall acceptability S2 could be regarded as the best salad dressing recipe. Addition of higher amount of sugar and lesser amount of vinegar may be the reason for better taste, smell and overall acceptability. With reference to the comments of the panelists the colour and the smell of the salad dressing should be improved. Unacceptable colour may be due to the addition of spices. The smell of vinegar could be avoided by addition of vanilla.

Table 07. *Probability values and mean scores of sensory attributes of salad dressing recipes*

Parameters	p value	Mean scores		
		S1	S2	S3
Taste	0.0001	3.96	4.83	1.73
Smell	0.0001	3.56	4.16	2.63
Colour	1.000	3.16	3.16	3.16
Overall acceptability	0.0001	3.73	4.76	2.33

Probability value (p 0.05) significantly different, N=30.S1=Fermented salad dressing. S2=Sweet salad dressing.S3=Sour salad dressing.

The taste, smell, colour, overall acceptability were not significantly different (probability value 0.05) among the four treatments (T1, T2, T3, and T4)(table 08). All the treatments showed lower mean scores for colour. However, T3 showed higher mean scores than those of T1, T2 and T4 for taste, smell, colour and overall acceptability (4.33, 4.20, 3.20, and 4.23 respectively). Results revealed that T3 could be regarded as the best treatment.
The addition of 0.01% of antioxidant, 0.13% of preservative may have improved the sensory attributes of prepared salad dressing.

Table 08. *Probability values and means scores of sensory attributes of salad dressings*

Parameters	P value	Mean scores			
		T1	T2	T3	T4
Taste	0.0539	3.08	3.86	4.20	3.90
Smell	0.0567	3.73	3.76	4.20	3.73
Colour	0.4918	2.96	3.03	3.20	3.0
Overall acceptability	0.2030	3.90	3.90	4.23	3.90

Probability value (p 0.05) significantly different, N=30

T1- Treated with 0.01% antioxidant and 0.1% stabilizer
T2- Treated with 0.13% preservative and 0.1% stabilizer
T3- Treated with 0.01% antioxidant and 0.13% preservative and 0.1%stabilizer
T4- Not treated

Except for colour all other sensory attributes of formulated salad dressing (SD1) were significantly different from market available salad dressing (SD2) (table 09).
Salad dressing SD1 showed higher mean scores than SD2 for taste, smell and overall acceptability (4.6, 4.2 and 4.2 respectively). While SD2 showed a higher mean score for colour. However, when the sensory attributes of taste, smell and overall acceptability are considered SD1 could be regarded as the better salad dressing. According to the comments of the panelists taste and the smell of the market available salad dressing (SD2) was unacceptable.

Table 09. *Probability values and mean scores of sensory attributes of best salad dressing and market available salad dressing*

Parameters	P value	Mean scores	
		SD1	SD2
Taste	0.0001	4.60	2.9
Smell	0.0001	4.20	2.80
Colour	0.0001	2.90	4.60
Overall acceptability	0.0001	4.20	2.85

Probability value (p 0.05) significantly different=30
SD1=Prepared salad dressing
SD2=Market available salad dressing

There is a significant difference between the two salad dressings for all the chemical parameters except peroxide value (table 10). Based on the results, prepared salad dressing is significantly different from market available salad dressing.

Table 10. *Chemical parameters of both type of salad dressings*

Parameters	Sample 1	Sample 2	$LSD_{0.05}$
Crude protein (%)	1.39 [a]	0.62 [b]	0.02
Total sugar (%)	15.62 [a]	8.91 [b]	0.04
Crude fat (%)	8.87 [a]	8.5	0.03
Peroxide value (%)	0.00 [a]	0.00 [a]	0.005
Free fatty acid (%)	0.01 [a]	0.00 [b]	0.05
Moisture content (%)	34.00 [a]	31.20 [b]	1.34
Ash content (%)	5.05[a]	2.02 [b]	0.03

Each value represents mean of replicates. The composition is given as a percentage on dry basis. Values dominated by same letter(s) are not significantly different at (LSD, P=0.05)

Sample 1=Prepared salad dressing
Sample 2=Market available salad dressing

Lauric acid (C12:0) was the most abundant fatty acid (45 %) found in the formulated salad dressing (table 11). However it showed higher amounts of Myristic (C14:0) and Palmitic (C16:0) and lower amounts of Stearic (C18:0), Linoleic (C18: 2) and Caprylic (C08:0) (2 %, 3 % and 5 % respectively). Market available salad dressing contained 32.72 % Lauric acid (C12:0), 20.63 % Myristic (C14:0), 17.12 % Palmitic (C16:0) and 17.38 % Oleic (C18: 1). Sample one contained a higher amount of Lauric acid C 12:0 (45 %) and a lesser amount of Stearic acid C18:0 (2 %). Oleic acid (C18: 1) content in sample two was higher (17.38 %) compared to that of sample one (6.0 %). However both samples contained similar amounts of Stearic acid C18:0. The difference in fatty acids of both formulated and market available salad dressing may be due to the different oils used.

Table 11. *Fatty acid composition (%) of prepared salad dressing (sample one) and market available salad dressing (sample two)*

Name of free fatty acid		Peak area (%)	
		Sample one	Sample two
Caprylic acid	(C 08:0)	5.0	1.73
Capric acid	(C10:0)	6.0	2.13
Lauric acid	(C12:0)	45.0	32.72
Myristic acid	(C14:0)	20.0	20.63
Palmitic acid	(C16:0)	10.0	17.12
Stearic acid	(C18:0)	2.0	3.03
Oleic acid	(C18: 1)	6.0	17.38
Linoleic acid	(C18: 2)	3.0	5.22

Total microbial count of less than 15 colonies/g was observed for each treated salad dressing during four months period. It was also found that no significant microbial growth was observed either in the presence or absence of preservative. This may be due to the storage temperature (below 4 ^{0}C). Therefore it is recommended that the salad dressing, which was untreated, is good for human consumption since it does not carry any chemical preservatives. There was no significant change in free fatty acid content and peroxide value during four months storage period.

The study shows the possibility of manufacturing salad dressing using coconut oil with higher acceptability. Further research should be carried out to develop colour and texture of the product. Tart taste and smell of vinegar can be overcome by adding more sugar and vanilla respectively.

M. Jayasundera, S.P.K. Samarasinghe & T.S.G Fonseka

Experiment 04: Formulation of a skim milk beverage

(a). Preparation of coconut skim milk

Coconuts were grated (1500 g) and chilled at 5 $\pm$ 2 °C overnight. Coconut milk was extracted with the use of a hydraulic pressing machine without addition of water. Two other extractions were done with 300 ml each chilled water.

(b). Preparation of skim milk beverage concentrate

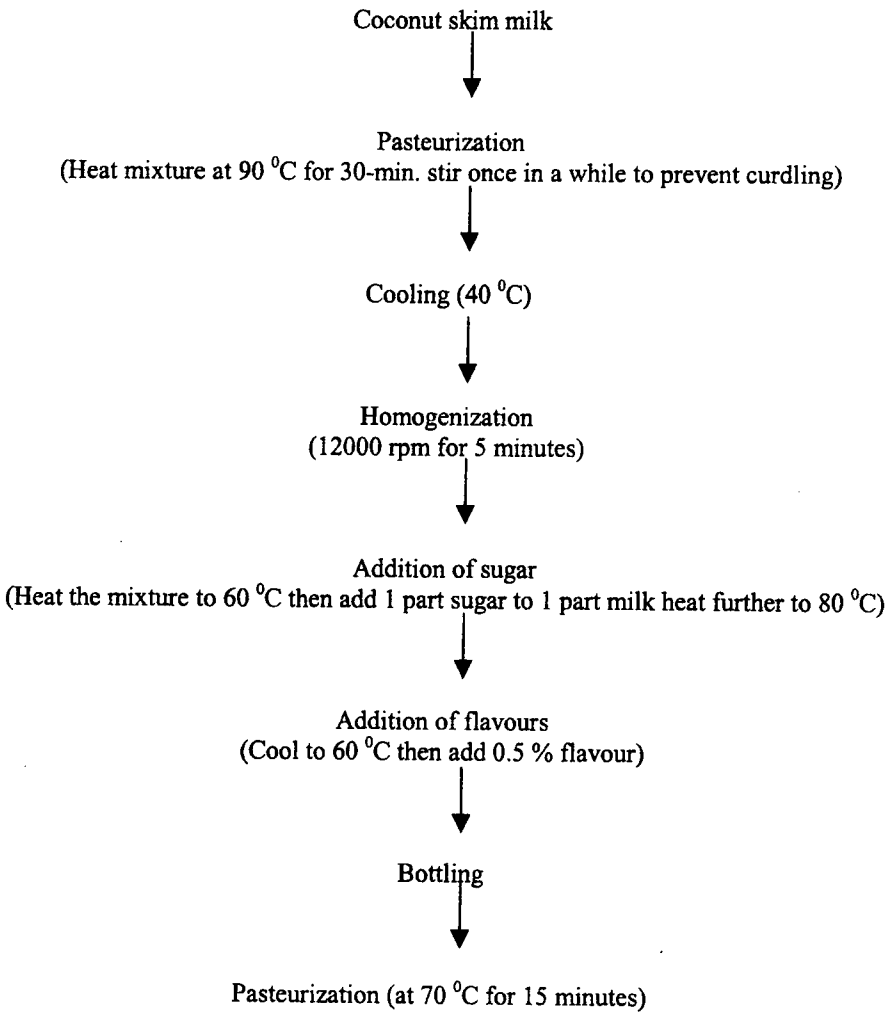

Fig.01: *Flow diagram for processing of skim milk beverage concentrate*

Treatments

T1-Treated with 0.035 % preservative (sodium metabisulphate) +0.5 %flavour
T2-Treated with 1% stabilizer (carboxy methyl cellulose) +0.5 %flavour
T3-Treated with 1% stabilizer (carboxy methyl cellulose) +0.035%preservative (sodium metabisulphate) + 0.5 % flavour
A sample without any treatment was taken as control

Chemical analysis of the beverage

The formulated beverage was analyzed for pH, TSS, moisture, fat, protein, sugar and mineral contents.

Sensory evaluation

The products of different treatments were sensory evaluated based on flavour, texture, taste, colour and general acceptability to determine the most acceptable treatment .The product was diluted with water in 1:3 ratio and presented to 30 semi-trained panelists. Five-point Hedonic scale (1-Dislike very much and 5-Like very much) was used for evaluation. The results were analyzed by Kruskal-Wallis test in Statistical Analysis System (SAS) software package.

Shelf-life studies

Shelf-life studies were carried out at monthly intervals for a period of 4 month.

Chemical analysis of coconut milk & coconut skim milk

The pH and mineral content did not vary much between CM & CSM (Table 12). However a slight lowering of the results in CSM was noticed. Moisture and Protein contents increased considerably in coconut skim milk and this is obviously due to removal of fat, one of the main components of coconut milk.

Table 12. *Chemical composition of coconut milk & coconut skim milk*

	pH	TSS (°Brix)	Moisture (%)	Total sugar (%)	Fat (%)	Protein (%)	Ash (%)
Coconut milk (CM)	6.3^{a}	17.0^{a}	49.6^{a}	5.2^{b}	40.0^{a}	3.9^{b}	1.3^{a}
Coco skim milk (CSM)	6.2^{a}	9.0^{b}	84.5^{b}	6.4^{a}	3.6^{b}	4.4^{a}	1.1^{a}

Chemical analyses of skim milk beverage concentrate

Results showed that pH, TSS, protein, fat and mineral content of all treated samples did not vary significantly ($p>0.05$)(table 13).

Table 13. *Chemical composition of beverage concentrates with different treatments*

Treatments	pH	TSS (°Brix)	Moisture (%)	Ash (%)	Total sugar (%)	Protein (%)	Fat (%)
Control	5.6^{a}	60^{a}	36.6^{a}	0.9^{a}	57.0^{b}	2.7^{a}	2.8^{a}
1	5.5^{a}	60^{a}	35.9^{b}	0.8^{a}	57.8^{a}	2.6^{ab}	2.9^{a}
2	5.6^{a}	59^{b}	40.5^{c}	0.8^{a}	53.3^{c}	2.6^{ab}	2.8^{a}
3	5.6^{a}	60^{a}	41.2^{d}	0.8^{a}	52.9^{c}	2.5^{b}	2.6^{a}

Means with same letters are not significantly different p=0.05

Sensory evaluation of the products

Table 14 shows the mean scores of sensory attributes of coconut skim milk beverage concentrates.

Table 14. *Mean scores of sensory attributes of skim milk beverage concentrates*

Treatment	Flavour	Colour	Taste	Overall Acceptability
Control	78.10^{a}	52.86^{a}	63.75^{a}	62.16^{a}
1	68.03^{b}	57.93^{b}	63.10^{a}	58.63^{b}
2	46.95^{c}	64.23^{c}	48.51^{b}	54.55^{c}
3	48.91^{c}	66.96^{d}	66.63^{c}	66.65^{d}

Mean with the same superscripts are not significantly different at p=0.05

Results of the Analysis of Variance (ANOVA) showed that the products were significantly different in flavour, colour, taste and overall acceptability. The highest mean score for flavour was obtained for the control. The mean scores for flavour of treatments 2 and 3 were not significantly different. Mean scores for colour in all the cases were significantly different. The taste was not significantly different between the control and treatment 1 however; it was significantly different between treatments 2 and 3. Overall acceptability was significantly different among all the beverage concentrates. According to sensory attributes of colour, taste and overall acceptability, the treatment 3 could be regarded as the best treatment.

Analysis of the Ready-to-Drink Beverage

The chemical composition of ready to drink beverage (diluted in 1:3 with water) made from treatment 3 is shown in table 14.

Table 14. *Chemical composition of Ready-to- Drink Beverage*

Treatment	Protein (%)	Fat (%)	Sugar (%)	Moisture (%)	Mineral (%)
3	1.0	0.8	18.7	79.2	0.3

Physical changes of the skim milk beverage concentrate

Almost three weeks after processing of the product a slight separation of the solid component from the aqueous phase was already evident on all the treatments. As the storage period lengthened the separation became more apparent in the control than in samples subjected to treatment. However the separation was less in the treated samples (2&3).

Microbiological analyses of the concentrate

The changes in microbial counts of the products were minimal during the four months of storage. The products having been exposed to the heat treatment with large amounts of sugar are bound to last for a longer period of time. The water needed by the organisms for growth was made unavailable by tying them up to the sugar molecules thus effectively controlling microbial growth.

Table 15. *Total plate count (colonies/g sample) of beverage concentrate*

Storage (month)	Control	Treatment 3
	X 10^{1}	X 10^{1}
1	0.0	0.0
2	10	0.0
3	15	5
4	20	10

Compared to the control the total plate count was less in treatment 3 during 4 months of storage under ambient temperature(30 ± 2 °C).

Results indicated that coconut skim milk could be utilized successfully in the processing of coconut skim milk beverage concentrate. The beverage concentrate was found to be stable for 4 months of storage under ambient temperature (30 ± 2 °C).

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Experiment 05: Instant thosai sambol based on defatted coconut powder

The ingredients needed for instant thosai sambol is given in table 16.

Table 16. *Quantities of ingredients*

Ingredients	Amount (g)
Defatted coconut powder	1000
Chillies	150
Maldive fish	50
Garlic	10
Curry leaves	10
Pepper	10
Onion	100

The ingredients were dried until the moisture content was less than 2 % and was ground into a powder. The ready to use form was prepared by mixing it in 1:4 with water and a little limejuice. Shelf life studies are being carried out.

M. Jayasundera & A.N. Kumara

Experiment 06: Dry Processing of virgin coconut oil and value addition to virgin coconut oil

Analytical parameters of virgin coconut oil were within the SLS specifications. Shelf life studies are being carried out for virgin coconut oil and value added virgin coconut oil. The mean analytical parameters of virgin coconut oil on two years of storage are given in table 17.

Table 17. *Mean analytical parameters of virgin coconut oil on 2 years of storage*

Analytical parameter	Value
Moisture %	0.4
FFA % as lauric acid	0.16
Iodine value	6.2
Peroxide value,meq/kg	0.4

Analytical parameters were still within SLS specifications even after 2 years of storage at ambient conditions.

M.Jayasundera, A.Dharmasena & S.Jayatilake

Experiment 07: Manufacturing of coconut water vinegar and some observation of physico-chemical and sensory qualities of the product

Vinegar is a condiment used as an additive for the preparation of various dishes and normally coconut vinegar is prepared using coconut sap or toddy. Nowadays it is very difficult to find natural coconut vinegar. However coconut water, a waste of Desiccated coconut mill/ copra industry can be utilized for vinegar preparation. This study was carried out to develop an appropriate low cost vinegar making technology and evaluate the physico chemical, microbial and sensory qualities. The technology developed consists of a two stage fermentation of sweetened coconut water, namely alcoholic and acetic fermentation.

Yeast Fermentation

Changes in alcohol content during the natural fermentation of sweetened coconut water for vinegar production are shown in figure 02.

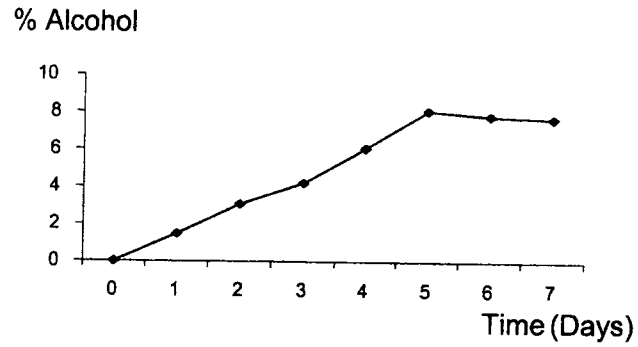


Fig.2. *Changes in alcohol % during Yeast Fermentation*

The alcohol content increased rapidly during the first few days of yeasts fermentation and reached to a maximum concentration of about 8% after 5 days and then it tends to decrease. In this process, added sucrose and invert sugars are hydrolyzed to ethyl alcohol by a particular yeast, *Saccharomyces cerevisiae*.

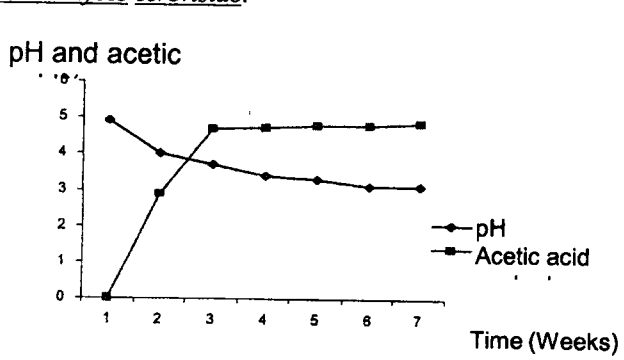


Fig 3.*Changes in pH and acetic acid% during acidic fermentation of mother vinegar added sweetened coconut water*

Figure 03.Shows the changes in pH and acid content. Two weeks later acetic acid concentration of the solution reached to 4.68 and then to 4.80 at 5th week in the sample with added mother vinegar. However acetic acid concentration remained at 0.3% during the entire studied period in the sample without mother vinegar. In this acetic fermentation, the ethyl alcohol from the first stage is oxidized to acetic acid (vinegar) by the bacterium (*Acetobacter acetei*)

Table 18 shows the specific gravity, total soluble solids (TSS), titratable acidity and microbial quality more or less similar to commercial natural vinegar. BUSY

Table 18. *Physico–Chemical & microbial properties of vinegar*

Parameters	Coconut water vinegar	Commercial coconut toddy vinegar	Commercial artificial vinegar
1.Specific gravity	1.02	1.01	1.00
2.Total soluble solids%	3.93	3.48	2.82
3.Titratable acidity	4.80	4.89	6.02
4.Aerobic plate count	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$
5.Total coliform count	negative	negative	negative

Table19. *Mean sensory evaluation scores of "Sinhala pickle" prepared with different kind of vinegar*

Kind of vinegar	aroma	appearance	texture	sourness	General acceptability
1.Coconut water vinegar	7.33	7.86	7.66	7.53	7.60
2.Commercial coconut toddy vinegar	7.00	7.66	7.53	7.36	7.36
3.Commercial artificial vinegar	7.40	7.80	7.80	7.53	7.70

The sensory qualities of the coconut water vinegar, commercial toddy vinegar and artificial vinegar are compared in table 19. The acceptability of the tested vinegar in the preparation of "Sinhala Pickle" was not significantly different.

K.D.P.P.Gunathilake & A.N.Kumara

Experiment 08: Development of fiber enriched noodles using coconut flour

Coconut flour is produced from residues obtained after extracting coconut oil from grated coconut or comminuted fresh coconut meat. Coconut flour is a good source of dietary fiber, which can reduce occurrence of non-communicable diseases. Therefore an experiment was conducted with the objectives of producing low-fat coconut flour at household level and development of fiber rich noodles using coconut flour.

Table 20. *Nutrient composition of coconut flour produced using household method and industrial method.*

Component	# composition (%)		
	Household method	Industrial method	P value
	Mean ± SD	Mean ± SD	
Moisture	1.80 ± 0.60	4.20 ±0.23	0.003
Ash	0.84 ± 0.12	5.96 ±1.19	0.002
Crude fat	19.83 ± 7.31	8.42 ±0.87	0.055
Crude protein	2.40 ± 0.13	21.65 ±0.06	0.0001
Crude fiber	23.04 ± 1.05	10.45 ±2.5	0.001
Carbohydrates (CHO)	52.09 ±13.02	59.77 ± 3.32	0.504

P values obtained by comparison of household method and industrial method using independent sample t-test

The potential of coconut flour to produce fiber rich noodles was evaluated by producing noodles with 0%, 10%, 20%, 30%, coconut flour. Sensory evaluations of coconut flour enriched noodles with commercial sample were assessed by 50 consumer panelists

Table 21. *Nutrient composition of noodles produced with different levels of coconut flour.*

Level of Substitution (%)	Composition (%)					
	Moisture Mean ± SD	Ash Mean ± SD	Crude fat Mean ± SD	Crude protein Mean ± SD	Crude fiber Mean ± SD	CHO Mean ± SD
0 (control)	10.31±0.08	2.57±0.09	0.005±0.001	11.22±0.06	0.00±0.00	75.90± 0.33
10	8.90±0.28	2.76±0.02	0.004±0.001	11.99±0.06	0.92±0.19	75.42± 0.78
20	11.17±0.46	3.81±0.04	0.004±0.002	14.33±0.51	1.94±0.21	68.74 ±1.73
30	10.08±1.48	3.32±0.01	0.020± 0.021	9.58±0.06	3.05 ±0.54	73.95 ±2.98

Table 22. *Results of sensory evaluation of coconut flour enriched noodles*

Evaluated quality parameters	Scores			
	0%	10%	20%	30%
Appearance and colour	4.00	4.00	4.00	3.00
Taste	4.00	3.80	3.90	3.70
Texture	4.00	4.00	4.00	3.00
Overall acceptability	4.00	3.90	3.80	3.00

It was observed that noodles prepared with coconut flour (up to 20%) are acceptable. Therefore coconut flour can be substituted with wheat flour up to 20% for noodles processing.

K.D.P.P.Gunathilake & Y.M.R.K.Abeynayake

Experiment 09: Value addition to coconut paste

Instant curry paste made out of quality raw materials is a product, which was demanded from modern society mainly for convenience. Although there are instant spice mixtures, which are prepared from various blends of spices already available in the market, products incorporated with coconut are not available and studies on development and preparation methods of these products are important. So this study was carried out to develop and evaluate physicochemical and sensory properties of instant chicken curry paste (coconut added), which would be acceptable to the consumer with attributes of maximum retention quality and longer shelf life.

Preliminary studies were conducted to find out the most suitable spices blend for chicken curry. Based on this study, the spice mixture was prepared. Coconut paste was prepared according to the method described in CRI Annual report (2002). Following flow chart shows the processing steps for Instant Chicken Curry Paste.

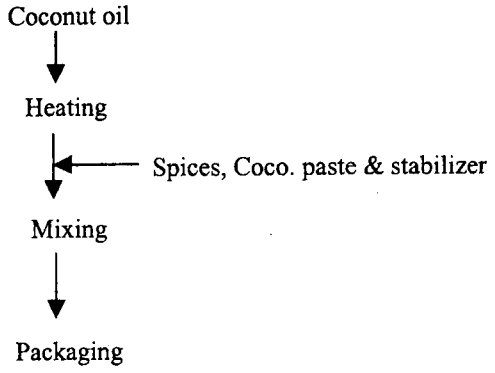


Fig.4. *Flowchart of processing Instant Chicken Curry Paste*

Table 23. *Proximate composition of coconut added chicken curry mix*

Constituents	%
Moisture	5.9+/-0.5
Ash	7.4+/-0.3
Crude fat	56.5+/-1
Crude protein	6.71+/-0.8
Crude fiber	4.21+/-0.5
Water activity	0.76

Crude fiber content of the paste is about 4.2% and this level is also high compared with use of coconut milk in the curry preparation.

Storage study

Instant chicken curry mix was packed in Nylon/LLDPE and Polyester/LLDPE laminated pouches and was stored at room temperature (28 +/-2^{0}C). Peroxide value, free fatty acids value, proximate composition and water activity and sensory properties were analyzed.

Results showed that over the whole storage period, overall acceptability remains within the same score of four in five point hedonic scale, irrespective of different types of packing materials and different levels of tocopherols.

Table 24. *Characteristics of treated instant chicken curry mix during storage at ambient conditions*

Sample	Storage Period (months)	FFA Value	Sensory score (overall acceptability)
A1	0	0.046	4.00
	2	0.053	4.00
	4	0.063	4.10
	6	0.073	3.90
A2	0	0.046	3.80
	2	0.054	3.98
	4	0.062	3.98
	6	0.073	3.78
A3	0	0.046	3.95
	2	0.050	3.68
	4	0.055	3.75
	6	0.072	3.70
A4	0	0.046	3.86
	2	0.052	4.01
	4	0.060	3.98
	6	0.069	4.00
A5	0	0.046	3.79
	2	0.055	3.83
	4	0.122	3.78
	6	0.140	3.80
A6	0	0.046	3.08
	2	0.053	3.00
	4	0.132	3.15
	6	0.160	3.00

(A1=control + Nylon/LLDPE packs, A2=control + Polyester/LLDPE packs, A3=50ppm tocopherol + Nylon/LLDPE packs, A4=50ppm tocopherol + Polyester/LLDPE packs, A5=100ppm tocopherol + Nylon/LLDPE packs, A6=100ppm tocopherol + Ployester/LLDPE packs)

The peroxide values were zero for all the treatment during the whole storage period. However changes in FFA level were not affecting on sensory properties of the product, because changes are comparatively low with other fatty foods. This may due to the use of good quality oil, antioxidant properties of spices, low moisture and water activity. Antioxidant properties of spices, rancidity development in the Instant curry paste is fairly low. Total plate count was used to evaluate the microbial load in the storage.

Table 25. *Changes in microbial load during storage*

Sample	Total plate count			
	Initial	2 months	4 months	6 months
A1	$2.1x10^2$	$4.4x10^2$	$6.5x10^2$	$9.0x10^2$
A2	$2.1x10^2$	$4.6x10^2$	$7.0x10^2$	$8.9x10^2$
A3	$2.1x10^2$	$3.8x10^2$	$7.5x10^2$	$9.9x10^2$
A4	$2.1x10^2$	$5.0x10^2$	$8.0x10^2$	$1.0x10^2$
A5	$2.1x10^2$	$4.9x10^2$	$7.0x10^2$	$8.9x10^2$
A6	$2.1x10^2$	$4.7x10^2$	$7.2x10^2$	$9.6x10^2$

(A1=control + Nylon/LLDPE packs, A2=control + Polyester/LLDPE packs, A3=50ppm tocopherol + Nylon/LLDPE packs, A4=50ppm tocopherol + Polyester/LLDPE packs, A5=100ppm tocopherol + Nylon/LLDPE packs, A6=100ppm tocopherol + Polyester/LLDPE packs)

It was increased during the studied period but product was in the safety level. This may be due to low moisture level, low water activity and spices; spices have naturally containing antimicrobial properties such as bactericides, bacteriostatic etc. Coconut paste has low water activity, so use of coconut in the form of coconut paste would extend the keeping quality. Total colony counts were within the range of safety levels and product is microbiologically safe at least for a period of six months.

K.D.P.P.Gunathilake & A. Bandara

Experiment 10: Development of a sports drink using seasoned nut water

Table 26. *Chemical properties of coconut water*

Property	Coconut water
pH	5.1
Total soluble solids	4.8%
Acidity	0.12%

The preliminary studies were carried out to develop a method to prepare the sports drink with suitable pasteurization conditions. First single heat treatment was given with four different time-temperature combinations. They were 77 °C/ 20 min, 71°C/ 30min, 70°C/ 20 min and 65°C/ 30min and stored under room and cold temperature conditions. With the storage, cloud formation was observed in all above time- temperature conditions.

Another preliminary study was done with two heat treatments along with filtration. At first coconut water was given a high heat treatment of 95 °C for 15 min and filtered immediately after the heat treatment by using a cotton wool bed. The coconut water treated in this way used for the preparation of sports drink. However the cloud formation with the prolonged storage happens in this treatment too. In order to completely remove the appearance of cloud, heat-treated coconut water was stored in cold room for a period of 8 to 10 hours and then filtered with cotton wool bed before the preparation of the sports drink. This process did not give cloud formation but slight sediment was observed at the bottom of the bottle. Therefore the same treatment was improved by giving another filtration step prior to final pasteurization. This final process gave neither cloud nor sedimentation and it was selected for the preparation of sports drink. Microbial plate counts were carried out with the final products of above selected method and products were negative for the microbial counts. Therefore final process was used for the preparation of the bulk samples of both artificially and naturally flavoured sports drinks. A summary of the results obtain from this experiment is shown in the following table

Table27. *Changes in Physico-Chemical parameters of Sports Drink*

Time(month)	Treatment	pH	T.A %	TSS
1	Artificial-room	3.2	.24	10
	Artificial-cold	3.2	.24	10
	Natural-room	3.2	.23	10
	Natural-cold	3.1	.24	10
4	Artificial-room	3.1	0.23	10
	Artificial-cold	3.2	0.24	10
	Natural-room	3.2	0.25	10
	Natural-cold	3.0	0.30	9
7	Artificial-room	3.3	0.26	10
	Artificial-cold	3.2	0.26	10
	Natural-room	3.3	0.26	10
	Natural-cold	3.3	0.28	10
9	Artificial-room	3.3	0.27	10
	Artificial-cold	3.3	0.27	10
	Natural-room	3.2	0.28	9.8
	Natural-cold	3.3	0.27	9.5

[Note: T.A% - Titraitable acidity, TSS – Total soluble solids]

It was observed that there was no significant difference in pH, titraitable acidity and TSS between the two products under cold and room temperature storage conditions during the period of storage. This indicates that the pH and titratable acidity had not contributed for the change of flavour of the product.

Pasteurization and cloud formation

Coconut water is a nutritious solution that contains protein and other nitrogenous compounds which causes problems in heat processing. When the coconut water is treated at a temperature above 65°C part of its protein gets denatured and settles down and these cause the cloud formation. The time required for the processes dependant on the severity of the heat treatment. Lower the heat treatment, longer the time need to form the cloud. The heat treatments below 65°C have the problems of microbial stability of the final product. Therefore it is difficult to produce stable cloudless product with single heat treatment.

Filtration

After the heat treatment is given to the coconut water, filtration is a method that can be used to remove the cloud. However when the coconut water is filtered immediately after the heat treatment, is not successful because the settling down process of the denatured protein is incomplete and cloud appears during storage. If the heat treated coconut water is kept at room temperature conditions, it takes a long time period for the deposition of all denatured proteins. Therefore, heat-treated coconut water was kept under cold conditions to accelerate sedimentation and 8 to 10 hours of storage under cold condition is sufficient for the complete deposition of denatured proteins. No flavour changes occur due to the fermentation of coconut water during this storage period. For the filtration process, cotton wool bed is good enough for the complete removal of the denatured protein.

Artificially flavoured sports drinks obtained higher ranks for both cold and room storage conditions compared to the natural sports drink. The artificially flavoured sports drink stored at cold temperature scored the highest ranks; they were 74 and 81.5 respectively for 4^{th} and 9^{th} months. Initially there was less difference between ranks for cold temperature stored products with their room temperature stored counterparts. But as time progresses the gap between ranks increases resulting

better ranks for cold stored products. The commercial sports drink obtained the lowest ranks for the flavour at all levels of shelf life study. Highest rank for the overall acceptability was recorded for the artificially flavoured sports drink stored at cold storage conditions. Generally artificially flavoured sports drinks scored better ranks over the naturally flavoured sports drinks throughout the shelf life study. The lowest score for overall acceptability was scored by the commercial sports drink. At each level of sensory evaluation two forms of coconut water sports drinks scored better ranks than the commercial sports drink.

Table 28. *Electrolytes composition of sports drinks*

ports drink	K (mg/100ml)	Na (mg/100ml)	Ca (mg/100ml)	Mg (mg/100ml)
Artificial	193	37	24	14
Natural	194	38	24	14
Commercial	30	42	2	2

According to the table the coconut water sports drinks have significantly high level of K concentration compared to the commercial sports drink. It also possesses higher level of Ca and Mg concentration although they are not indicated in commercial sports drink that gives advantage to the coconut water sports drink over the commercial sports drink. But in terms of Na concentration the coconut water sports drink has slightly low Na concentration than the commercial sports drink. When compared, the natural and artificial sports drinks here no significant difference in electrolytes concentration, indicating that the electrolytes were totally contributed by the coconut water.

According to the total sugar content, naturally and artificially flavoured sports drinks have higher levels of sugar concentrations than the commercial sports drink, but they are within the acceptable sugar concentration range of the sports drinks (6%-10%). The formulated coconut sports drinks contain added 6% sugars in the form of sucrose and glucose, and mainly the coconut water contributes the rest.

Microbiological analysis

Microbial counts during the period of shelf life evaluation were negative. Pasteurization conditions given to the coconut water prior to cold storage reduces the microbial count. During the beverage processing steps the repasteurization conditions given along with the low pH levels (3.2-3.4) and chemical preservatives destroyed all vegetative stages of microorganisms and their spores. With low pH values of the final product, the heat sensitivity of microorganism increases and the preservative action of chemical preservatives also increases. Hence microbial contaminations during the beverages can be controlled at repasteurization stage. Therefore final product is microbialy safe for the consumption even after 9 months of storage.

K.D.P.P.Gunathilake & C. Wimalasena

REPORT OF THE PLANT PHYSIOLOGY DIVISION
Head – C S Ranasinghe, Ph D

1. General

Research programme was mainly focused on drip irrigation and the physiological responses of coconut palm, growth and performance of coconut root system under different land suitability classes and shade levels, screening coconut genotypes for drought tolerance, evaluating the impact of CO_2 elevation in the atmosphere on improving the acclimatization protocol of embryo cultured plants, quality preservation of tender king coconuts and disorders of coconut palm.

Research project on determining the effect of drip irrigation on micro climatic conditions of the canopy and nut setting of adult coconut palms during dry periods showed that the temperature on the surface of developing nuts, within the canopy and in the manure circle (at 30 cm depth) and the leaf stomatal diffusive resistance declines with increasing rate of irrigation (40 L/ palm/day, or 80 L/ palm/day). However, since the experiment was started in June 2004, the tested palms were not exposed to a severe drought or high temperature stress during the year. A new experiment was started to determine the physiological performance and growth of the root system of coconut seedlings under drip irrigation. The experiments on evaluating the growth and performance of root system of coconut seedlings under different land suitability classes (S2, S3 and S4) were continued. After one year, the highest weight of primary roots and the lowest weight of tertiary roots were shown by the seedlings grown in S2. The highest and the lowest shoot dry weights were observed in the seedlings grown in S4 and S2 soils, respectively. The highest and lowest shoot to root ratio was shown by the seedlings grown in S4 and S2, respectively.

Field evaluation of PEG-screened embryo-cultured plants (plants survived in 3 – 6% PEG solution) for drought tolerance revealed that the stomatal diffusive resistance, rate of transpiration, starch, sugars and proline accumulation in leaves were not different among treatments during dry period. Hence it can be concluded that the PEG screening is not a suitable tool to select coconut embryo cultured plants for drought tolerance. A cluster analysis was conducted with the objective of identifying coconut forms or accessions (form/acc) with drought tolerance from the available coconut germplasm pool in the Coconut Research Institute using physiological parameters. *San Ramon Russet, San Ramon Green* and *Clovis* were identified as better performing form/acc than others under moderate water deficits while both *Dwarf Green X Tall* and *Dwarf Yellow X Tall also in the same cluster* due to their high rates of photosynthesis.

With the objective of improving the acclimatization protocol, embryo-cultured coconut plants were exposed to high CO_2 concentration (450-500 ppm) during the period of acclimatization. Vegetative and physiological performance of the plants is being monitored.

The protocol for quality preservation of tender king coconuts for a period of one month was obtained by 10 growers/ exporters during the year. Experiments were conducted for testing other fungicides to replace Benlate in the previously recommended protocol for shelf improvement of tender nuts as the use of Benlate is now banned in many countries. Captan (0.6 g / L) and Carbendazim (0.6 g / L) are being tested as suitable fungicides. Vacuum packing of disinfected coconuts under cold storage (13-15 °C) was identified as a suitable protocol for extending shelf life of up to 38 days for export purposes.

The productivity and cost effectiveness of seasonal production of coconut and toddy in the same coconut palm at three monthly intervals (coconut production in lean periods and toddy production in glut periods) was evaluated for increasing the productivity of coconut plantations. It revealed that nut and toddy producing palms increase the productivity of a plantation by giving an additional income from toddy without reducing the per palm nut yield

Leaf Scorch Decline (LSD) and Tapering Disorder (TD) affected palms were sprayed with complete nutrient solution (macro and micronutrients) at three-monthly intervals and the recovery of the palms was determined. After two years, the palms did not show a significant improvement in nutrients of the 14th frond. However, the level of some nutrients was improved compared to initial nutrient status in both healthy and affected palms after nutrient spraying. The type of increased nutrient varied with the location (Bandiripuwa, Walpita and Poththukulama). The chlorophyll content of the leaves was increased and the percentage of affected fronds was decreased in LSD-affected palms with spraying. Leaf chlorophyll content in TD-affected palms at BRS showed a significant improvement with the application of nutrients. Financial assistance was received from CARP for this study.

PROJECT 13: TODDY TAPPING

Experiment 13.6: Seasonal production of nut and sap in coconut palms. Bandirippuwa Estate, Lunuwila (2003).

The objective of the study is to use coconut palms for dual purpose of nut and toddy production for increasing the productivity of coconut plantations (nut production in lean periods and sap production in glut periods).

Treatments:

T1- Nut production only
T2- Periodic nut and toddy production at three monthly intervals

The number of nuts and volume of toddy produced by each palm and the quality of each produce were monitored. Nut and toddy producing palms increase the productivity of a plantation by giving an additional income from toddy without reducing the per palm nut yield (Table 1). The experiment was terminated.

Table 1: *Annual number of nuts and volume of toddy produced by single purpose (T1) and dual purpose (T2) trees*

Treatment	Year 1		Year 2	
	No. of nuts /palm	Toddy (L / palm)	No. of nuts /palm	Toddy (L / palm)
T1	31.5	-	33.1	-
T2	31.9	69.29	34.0	68.03

C S Ranasinghe, W P K K Fernando & A Jayathilake

PROJECT 22: POST-HARVEST HANDLING OF TENDER KING COCONUTS FOR QUALITY PRESERVATION.

Experiment 22.3: Development of a post-harvest technology to improve shelf-life of tender king coconuts.

The protocol for quality preservation of tender king coconuts for a period of one month was disseminated to 10 exporters during the year. Experiments were conducted to refine the existing protocol for preservation of tender nuts up to six weeks and enhance the acceptance of the product in overseas markets. It is apparent that the shelf-life of nuts can be improved up to 36 days by vacuum packing and cold storage (14-15 °C). The experiments are in progress.

Furthermore, use of Benlate (Benomyl) is now banned in many countries. Therefore, experiments were conducted for testing other fungicides to replace Benlate in the previously

recommended protocol. Captan (0.6 g / L) and Carbendazim (0.6 g / L) are being tested as suitable fungicides.

C S Ranasinghe, W S Madurapperuma, PS A de Saram, W P K K Fernando & M Gunawardane

PROJECT B-17: WATER RELATIONS OF THE COCONUT PALM

Experiment B-17.5: Effect of drip irrigation on micro climatic conditions of the canopy, soil temperature, button nut setting and yield (RE, 2003).

The drip irrigation trial conducted at Ratmalagara Research Station, by the Soils and Plant Nutrition Division, CRI is used for the study. The main objective of the study is to evaluate the effect of drip irrigation on the micro climatic conditions of the canopy, temperature in effective root zone and button nut setting of coconut palms. Eight palms each of the following three treatments were selected.

Treatments (source: SPND, CRI)

Treatment	Irrigation interval (days)	Application of water (L per day/ palm)	Application of water (hrs per day/ palm)	Application of fertilizer g / yr	No. of time of fertilizer application / yr
T1	-	-	-	3000	1
T5	6	40	2	250	12
T6	3	80	2	250	12

The following data was collected

1. Canopy temperature (at 7th bunch and 10th bunch levels, from 7.00 to 10.00 hr in the morning and from 13.00 to 17.00 hr in the afternoon)
2. Nut surface temperature (topmost nuts of 7th and 10th bunch, exposed to sunlight, from 7.00 to 10.00 hr in the morning and from 13.00 to 17.00 hr in the afternoon)
3. Soil temperature (1 m away from the base of the palm, at 30 cm depth, from 7.00 to 10.00 hr in the morning and from 13.00 to 17.00 hr in the afternoon)
4. Number of female flowers produced and button nut setting
5. Stomatal diffusive resistance (from 9.00 to 13.00 hr)

Soil temperature, nut surface temperature (tender and mature bunches) and stomatal diffusive resistance showed a declining trend with the rate of irrigation, however, the differences were statistically not significant (Table 2). Since the experiment was started in June 2004, the tested palms were not exposed to a severe drought or high temperature stress during the year.

Table 2: *Variation in soil temperature, nut surface temperature (tender and mature bunches) and stomatal diffusive resistance leaves of irrigated and unirrigated (control) palms.*

Treatment	Soil Temp (C)		Nut surface Temp (C) – bunch 7		Nut surface Temp (C) – bunch 10		Stomatal diffusive resistance ($cm\ s^{-1}$)
	7.00–10.00	13.00-16.00	7.00–10.00	13.00-16.00	7.00–10.00	13.00-16.00	9.00–13.00
T1	28.7± 0.14	29.1± 0.20	30.9± 0.38	31.5± 0.14	30.4± 0.10	31.1± 0.14	4.55± 0.38
T5	28.3± 0.11	28.5± 0.12	29.5± 0.35	30.9± 0.17	30.0± 0.35	30.9± 0.17	4.21± 0.24
T6	28.2± 0.14	28.4± 0.15	29.5± 0.31	30.7± 0.14	29.4± 0.28	30.7± 0.14	3.96± 0.22

Mean ± std error values are given

C S Ranasinghe, A Nainanayake, R D N Premasiri & L R S Silva

Experiment: Evaluation of coconut seedlings under drip irrigation

A new experiment was started at Bingiriya to determine the pattern of root growth and physiological performance of coconut seedlings, when they were raised under drip irrigation. Site selection and field arrangements were already completed and the seedlings are ready for field planting.

A Nainanayake, R D N Premasiri & L R S Silva

Experiment B-17.6: Field evaluation of embryo-cultured plants screened for drought tolerance (Lenawa Estate, 2003).

The objective of the study is to evaluate the field performance of embryo-cultured seedlings using physiological and biochemical parameters that survived in different levels of PEG solutions.

Treatments

T1 – Plants survived in 3% PEG solution
T2 – Plants survived in 4% PEG solution
T3 – Plants survived in 5% PEG solution
T4 – Plants survived in 6% PEG solution
T5 – Control (nursery raised seedlings)

The rate of transpiration, stomatal diffusive resistance, leaf water potential and leaf biochemical parameters (starch, sugar and proline contents) were measured at monthly intervals. The experiment was conducted for three consecutive years and neither physiological (Table 3) nor biochemical parameters (Table 4) were significantly different among the treatments (survived PEG level) during wet or dry periods. Therefore, it can be concluded that PEG screening is not a suitable method for screening embryo-cultured coconut plants for drought-tolerance. The data collection was terminated.

Table 3: *Rate of transpiration and stomatal diffusive resistance of PEG-screened coconut palms and nursery raised seedlings (control) during wet (200 mm / month) and dry periods (50 mm / month) of the year.*

Mean ± std error values are given

Treatment	Rate of Transpiration ($\mu g\ cm^{-2}\ s^{-1}$)		Stomatal diff. resistance ($s\ cm^{-1}$)		*Leaf water potential (MPa)*	
	Wet period	Dry period	Wet period	Dry period	Wet period	Dry period
3 % PEG	3.76 ±0.15	0.50 ± 0.04	4.26 ±0.13	53.73 ± 6.8	1.52 ± 0.04	0.73 ± 0.05
4 % PEG	3.2 ± 0.22	0.62 ± 0.06	5.45 ± 0.62	44.5 ± 4.56	1.43 ± 0.08	0.73 ± 0.04
5 % PEG	3.52 ± 0.22	0.51 ± 0.06	4.93 ± 0.32	57.84 ± 7.74	1.46 ± 0.12	0.77 ± 0.04
6 % PEG	3.0 ± 0.12	0.52 ± 0.04	5.44 ± 0.25	58.01 ±7.29	1.45 ± 0.02	0.81 ± 0.05
Control	3.0 ± 0.18	0.40 ±0.03	5.63 ± 0.38	57.23 ±10.3	1.35 ± 0.07	0.63 ± 0.03
Sig	ns	ns	ns	ns	ns	ns

Table 4: *Leaf starch, sugar and proline contents of PEG-screened coconut palms and nursery raised seedlings (control) during wet (200 mm / month) and dry periods (50 mm / month) of the year.*

Mean ± std error values are given

Treatment	Leaf starch content ($mg\ g\ dw^{-1}$)		Leaf sugar content ($mg\ g\ dw^{-1}$)		Leaf proline content ($\mu g\ g\ dw^{-1}$)	
	Wet period	Dry period	Wet period	Dry period	Wet period	Dry period
3 % PEG	96.02± 9.54	34.77± 4.71	95.02± 9.54	74.34±2.79	266.3± 37.4	236.25±27.58
4 % PEG	96.16± 4.16	67.41± 1.88	87.41± 4.16	67.41±1.88	284.2± 25.9	222.98±38.61
5 % PEG	90.21±6.35	39.47± 2.18	78.19± 6.35	72.45±1.99	303.2± 37.4	256.41±37.95
6 % PEG	94.81± 10.8	54.85± 1.50	84.66± 10.8	77.35±2.33	285.7± 35.0	227.54±17.67
Control	93.72± 8.07	28.90± 3.81	81.73± 8.11	70.80±2.11	364.26± 96.3	380.28±45.0
Sig	ns	ns	ns	ns	ns	ns

C S Ranasinghe, R D N Premasiri, L R S Silva, W P K K Fernando & P S A de Saram

Experiment B-17.6: Screening coconut palms (*Cocos nucifera* L.) for drought tolerance using physiological, biochemical and molecular traits (2001).

The main objective of this experiment was to identify coconut forms or accessions (form/acc) with drought tolerance from the available coconut germplasm pool in the Coconut Research Institute using physiological parameters. A criterion for rapid selection of coconut palms for their putative drought tolerance was a long felt requirement in view of the long generation period of about 15 years for the establishment of a new bearing coconut palm with stabilized yield. The emphasis was on form/acc that might show substantial yields under drought conditions rather than mere survival. Physiology based rapid evaluation criteria instead of time consuming, yield based methods were tested. Forty form/acc comprising of local and exotic dwarfs, tall forms, king coconuts and hybrids (Table 5) from the collection of germplasm at Pottukkulama Research Station (PRS), Pallama was selected for the study.

Table 5: *Coconut accessions used in the field experiment including abbreviations used*

Variety	Forms		
typica (Talls)	*Wellawa (WL)*	*Moorock (MO)*	*Debarayaya (DBY)*
	Pitiyakanda (PI)	*Namalwatta (NW)*	*Clovis (CL)*
	Palugaswewa (PW)	*Ambakelle Special (AS)*	*Razeena (RA)*
	St. Annes (SA)	*Margaret (MA)*	*Kasagala (KS)*
	Melsiripura (MP)	*Mangalaeliya (ME)*	*Goyambokka (GB)*
	Goluwapokuna (GP)	*Keenakelle (KK)*	*Maliboda (MB)*
	San Ramon Green (SRG)	*San Ramon Russet (SRR)*	*Horakelle (HK)*
	Navasi (NV)	*Bodiri (BD)*	*Walahapitiya (WP)*
	Gon Thembili (GT)	*Navasi Thembili (NT)*	*Kamandala (KD)*
			Porapol (PP)
nana (Local Dwarfs)	*Dwarf brown (DB)*	*Dwarf (Kundasale) (KUD)*	*Dwarf Red (DR)*
	Dwarf Yellow (DY)	*Dwarf Green (DG)*	
nana (Exotic Dwarfs)	*Cameroon Red Dwarf (CRD)*	*Brazilian Green Dwarf (BGD)*	
aurantiaca (*King coconuts*)	*King coconut (KC)*	*Rathran Thembili (RTT)*	*Ran Thembili (RT)*
Hybrids	*Dwarf Green x Tall (DT)*	*Dwarf Yellow x Tall (DYT)*	

The cluster analysis was conducted using a few derived key physiological parameters from basic physiological data which were identified as important indicators in response to drought. The minimum soil moisture content of the top 150 cm of the soil (θ_{150min}) was the main driving force for all cascades of changes in plants under drought. The *RWC* at θ_{150} = 17%, ($RWC_{\theta 150=17\%}$) and minimum *RWC* (RWC_n) revealed differences in leaf water status of form/acc during the mid and latter part of the drought while leaf water potential (Ψ) at *RWC* = 75% ($\Psi_{RWC=75\%}$) showed the differences in cell wall elasticity. The maximum rate of photosynthesis (A_{max}) and A at 17% of θ_{150min} ($A_{\theta 150=17\%}$) and intrinsic water use efficiency at 17% of θ_{150min} ($\omega_{i\ \theta 150=17\%}$) indicated varietal potentials and efficiencies for production in favourable and moderately moisture stress conditions. The calculated drought susceptibility index (*SI*) using initial and final A and ω_i values ($SI_{(A)}$, $SI_{(\omega i)}$) were also used as an alternative measure of photosynthetic drought response. All parameters were expressed as percentage differences from the mean across all form/acc ($[X_i - \overline{X}]/\overline{X}$)x100. Cluster analysis for above key parameters was used to identify similarities differences between form/acc based on their grouping pattern into clusters with the dendrogram approach.

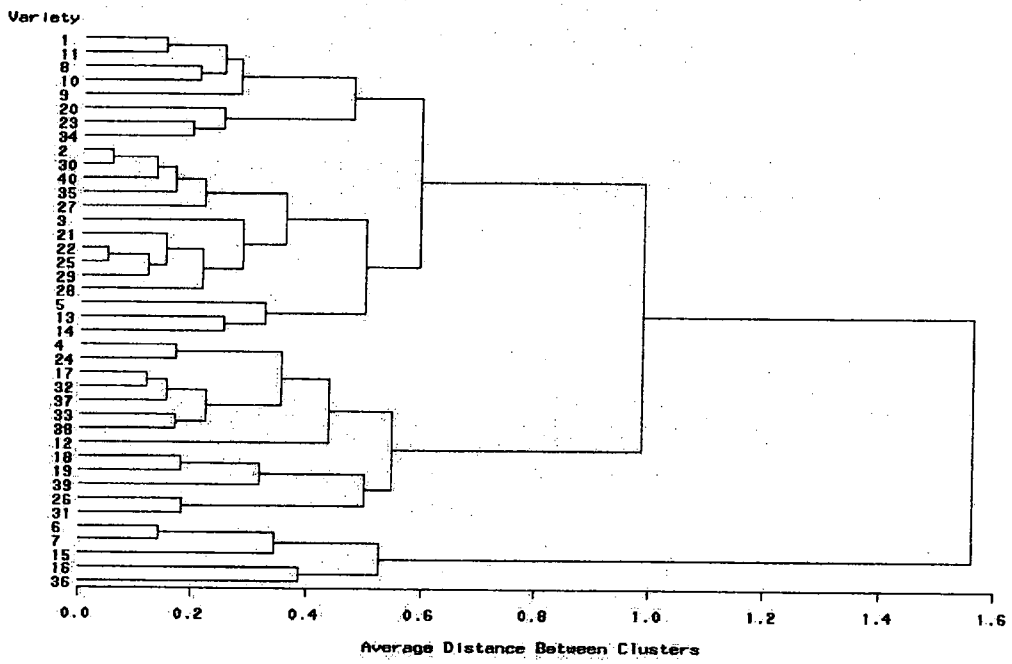


Fig.1. *Dendrogram showing the clustering pattern of form/acc based on mean percentage differences of each form/acc ($[Xi - \overline{X}]/\overline{X}$)x100 of 5 parameters [minimum θ_{150} (θ_{150min}), maximum A in well rain-fed conditions (A_{max}), A at θ_{150} = 17% ($A_{\theta150=17\%}$), ω_i at θ_{150} = 17% ($\omega_{i\,\theta150=17\%}$) and susceptibility index calculated on ω_i $SI_{(\omega i)}$].*

Three form/acc (*SRR, SRG, CL*) were clustered together and identified as better performing form/acc

under moderate water deficits while both *DT* and *DYT* joined the same cluster due to their high A max and $A_{\theta150=17\%}$. Maintenance of high internal water status even under depleting soil moisture conditions was important by enabling maintenance of high rate of photosynthesis. Thus evaluation of coconut palms using both internal water status (*RWC* or Ψ) and rate of photosynthesis was found important to identify drought tolerant form/acc in coconut.

A Nainanayake, R D N Premasiri, L R S Silva, P S A de Saram & M Gunawardane

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 (Raddegoda)**

From a breeding perspective, Dwarf Brown appears a more promising variety to employ as a parent material in developing new hybrids due to some characteristics such as non seasonality, high yielding capacity (higher no. of nuts per bunch and higher no of inflorescence per palm per year) and relatively high tolerance to water stress conditions compared to those of other dwarf varieties. This high potential of dwarf brown prompted plant breeders to develop more hybrids of Dwarf brown, crossing with identified tall varieties. It is expected to evaluate hybrid vigour of seven hybrids from a physiological point of view to identify hybrids which possess potential for higher vegetative growth and putative drought tolerance. The objective of the experiment is to identify potential varieties for higher hybrid vigour (vegetative growth) and putative drought tolerance under different agro-ecological regions by investigating physiological and water relations aspects.

Treatments

Eight varieties (DBxT, DBxSR, DGxT, DGxSR, TxSR, TxDB, TT, DB) are being tested with 9 seedlings per plot in a RCBD

Water relations, gas exchange and biochemical parameters will be monitored under moisture stressed and non stressed conditions.

A Nainanayake, R D N Premasiri, L R S Silva, W P K K Fernando & P S A de Saram

Experiment: **The effect of CO_2 elevation in the atmosphere on acclimatization of embryo-cultured plants.**

The objective of the experiment is to determine the effect of atmospheric CO_2 elevation during the period of acclimatization of embryo-cultured coconut plants on leaf production rate, leaf area development, growth of root system and gas exchange rates. Embryo cultured plants were placed in two open top chambers (4.3 m diameter x 2.8 m height, covered with UV treated polythene) at Bandirippuwa Estate, exposed to either elevated CO_2 (550-600 ppm) or ambient CO_2 (350-360 ppm). Vegetative and physiological performance of the plants is being monitored. The results of this experiment will be used for improving the acclimatization protocol of embryo-cultured plants.

C S Ranasinghe, L K Weerakoon, W S Madurapperuma & L R S Silva

PROJECT : **ROOT SYSTEM OF THE COCONUT PALM**

Experiment: **The growth of coconut seedlings under different land suitability classes (Bandirippuwa Estate, 2003)**

The objective of this study is to determine the development of root system of coconut seedlings in different land suitability classes (LSC) and its impact on other physiological parameters of the palm. TxT seedlings were planted in four different LSC (S1, S2, S3, S4). The shoot growth and related physiological and biochemical parameters are measured at three monthly intervals. Root growth will be measured at six monthly intervals by destructive sampling of seedlings.

After one year of seedling establishment, six seedlings from each LSC were uprooted to investigate the growth and development of root system. As the seedlings planted in S1 were severely damaged (by cattle), the experiment is being continued only with S2, S3 and S4. Seedlings grown under S2, S3 and S4 do not show a significant difference in number of primary, secondary and tertiary roots or root length one year after field planting (data not shown). Reason may be the provision of a better environment for root growth in the planting hole within the first year of planting. Dry weight of primary roots of the seedlings grown in S2, S3 and S4 are in decreasing order and the difference is statistically significant. In tertiary roots, dry weight is significantly different among three LSC and the highest weight was shown by the seedlings grown in S3. However, there is no significant difference in dry weight of secondary roots. The highest weight of primary roots and the lowest weight of tertiary roots were shown by the seedlings grown in S2 (Table 6). In primary roots, the volume was significantly different among the LSC, the highest showed by S2 and the lowest by S4 grown seedlings. However, there was no significant difference in volume of secondary and tertiary roots of the seedlings among the LSC (Table 6). The highest and the lowest shoot dry weights were observed in the seedlings grown in S4 and S2 soils, respectively, and the differences were statistically significant. Hence, the highest shoot to root ratio was shown by the seedlings grown in S4 LSC (Table 6).

Table 6 : *Dry weight and volume of primary (1ry), secondary (2ry) and tertiary (3ry) roots, shoot dry weight and Shoot/Root ratio (S/R) of seedlings grown under land suitability class 2, 3 and 4.*

	Root dry weight (g)			Root volume (cm^3)			Shoot dry weight (g)	Shoot/Root ratio
Suitability class	I ry	2 ry	3ry	I ry	2 ry	3ry		
S2	23.36 [a]	11.03	2.69 [c]	112.67 [a]	40.0	8.25	121.98 [c]	3.28 [b]
S3	20.13 [a]	12.02	6.71 [a]	76.17 [b]	45.6	6.37	187.42 [b]	4.82 [b]
S4	19.25 [b]	12.49	4.87 [b]	62.83 [c]	32.5	5.2	248.92 [c]	6.79 [a]
Significance	*	NS	***	*	NS	NS	***	**
CV	29.1	36.8	45.6	34.8	47.49	64.6	37.4	

W S Madurapperuma, R D N Premasiri, P S A De Saram & A Jayatilake

Experiment : The effect of Light Intensity on growth and development of coconut seedlings in different land suitability classes

Under planting of coconut seedlings at incorrect stage, when the mature plantation is still young and the light transmission to lower level is poor, has caused many problems such as poor growth of seedlings, late flowering etc in some coconut plantations. This experiment was conducted to evaluate the effects of low light intensity on the growth and development of under planted coconut seedlings. The seedlings were established in S2, either as an under plantation at low light intensity (40-50% PAR) or under an old coconut plantation with high light intensity (85-90% PAR). Experiment is being continued.

W S Madurapperuma, R D N Premasiri, P S A De Saram & A Jayatilake

PROJECT 24: DISORDERS OF COCONUT PALM

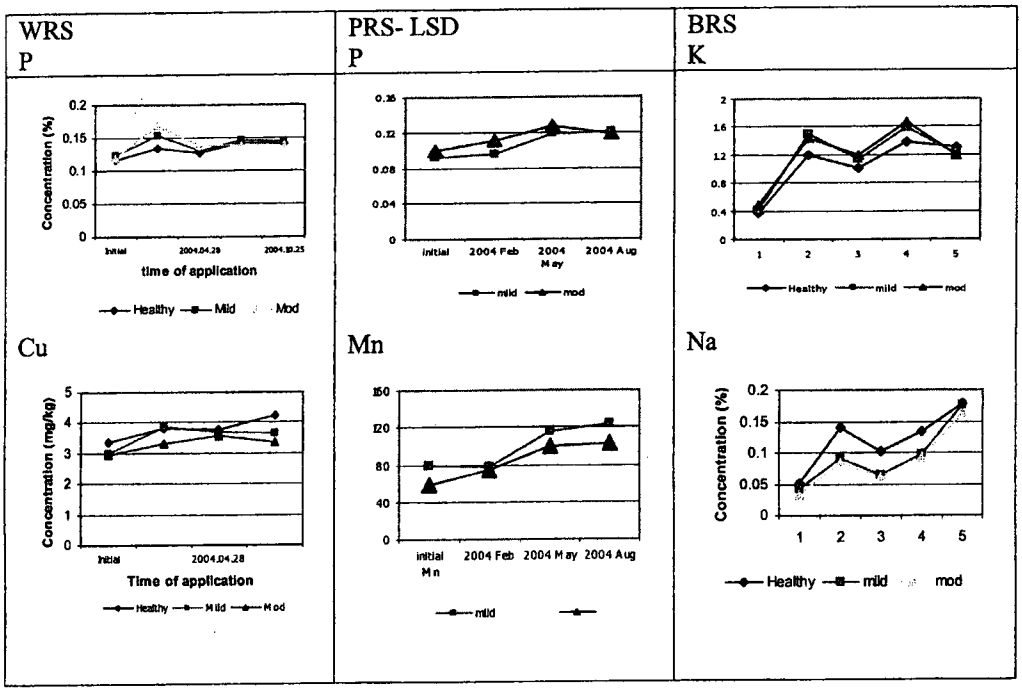
LEAF SCORCH DECLINE (LSD)

Experiment: Determine the effect of leaf spraying of macro and micro nutrients on the expression of LSD symptoms

The objective of this study is to investigate the effect of nutrient application through canopy spraying on the reduction of LSD symptoms and new root formation. The experiment was conducted at Bandiruppuwa (BRS), Poththukulama (PRS) and Walpita (WRS) Research Stations. Mild and moderate-LSD affected palms and healthy palms were selected for the experiment. Total nutrient solution including macro and micro-nutrients were sprayed to the canopy at three monthly intervals. Each time after application of nutrients, samples were taken from 14^{th} frond to analyse the nutrient status of palms. Samples were collected from 9^{th} frond to analyse chlorophyll content. Monthly observations of the total number of fronds and number of scorching fronds were done.

None of the palms showed a significant improvement of nutrients in the 14^{th} frond. However, the level of some nutrients was improved compared to initial nutrient status in all palms (healthy and affected). But this was not the same nutrient for all three locations. In BRS, K and Na showed an improvement, whereas in WRS and PRS, there was an improvement in P content. There was an increase in Cu and Mn in the WRS and PRS, respectively (Fig 2).

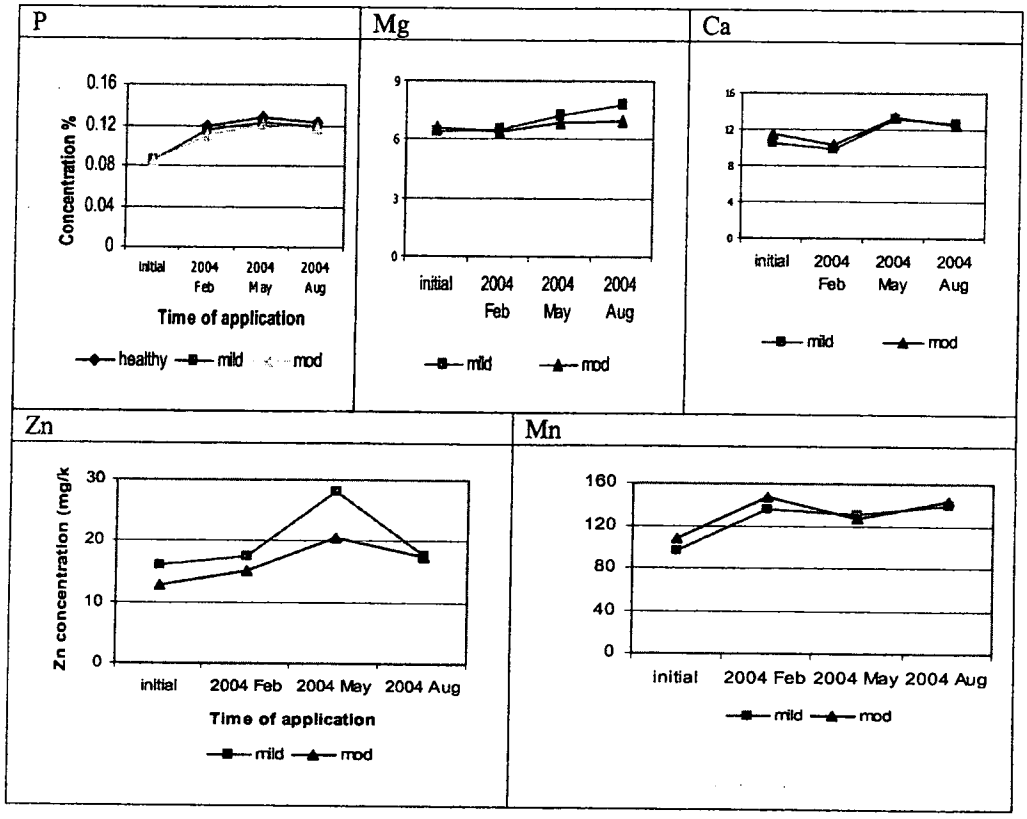
Fig 2: *Improvement of nutrients in LSD-affected palms following application of total nutrient solution at WRS, PRS and BRS.*



TAPERING DISORDER (TD)

TD-affected palms showed an improvement in P, Mg, Ca, Zn and Mn after application of total nutrients compared to initial nutrient levels (Fig 3).

Fig 3: *Improvement of nutrients in TD-affected palms following application of total nutrient solution.*



Leaf chlorophyll content in all three stages of TD-affected palms at BRS showed a significant improvement with the application of nutrients (Fig 4). However, neither chlorophyll content nor canopy characters showed any consistent improvement in TD-affected palms after treatment application at WRS or PRS.

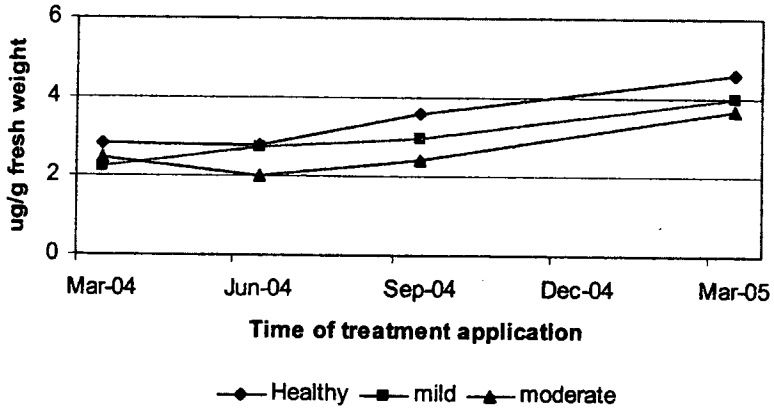


Fig 4: *Total chlorophyll content of leaves after application nutrients at BRS*

W S Madurapperuma, H C Mendis, C S Ranasinghe, R D N Premasiri & M Gunawardane

Awards

Mr N P A D Nainanayake, Senior Research Officer was awarded the Ph D degree by the University of Essex, UK on 15 November 2004

Report of the Technology Transfer Division 2004
Head - P A H Nimal Appuhamy, M Sc

1. GENERAL

Several progrmmes were implemented by the Division to transfer new technologies to coconut growers and the extension staff of the Coconut Cultivation Board (CCB). During the year priority was given to educate and upgrade the technical knowledge of extension field staff of CCB, particularly on recommended measures to manage coconut mite infestation. An accelerated programme was implemented in collaboration with CCB and other field level officials to promote the application of burnt engine oil mixture to control coconut mite. Several religious programmes and an International Conference on Coconut Research and Development were conducted to mark the 75th Anniversary of the Coconut Research Institute. Several farmer participatory programmes were conducted to promote technology transfer and adoption.

2. OTHER ACTIVITIES

2.1. Mrs. H D N H Fonseka, Assistant Extension Officer, continued post-graduate studies at the Postgraduate Institute of Agriculture, Peradeniya.

2.2 Mr. G Gunawardene, Extension Officer, continued postgraduate studies at the Agricultural University, Rajasthan, India.

3. ESTATE AND FARM DEVELOPMENT SERVICES

During the year, it was observed that there was a significant increase in the number of coconut growers who visited the Institute seeking technical advice for their problems. Separate arrangement were made to cater to the needs of these growers.

3.1 Advisory services to coconut growers

During the year, the staff of the division provided necessary guidance and advice to over 200 coconut growers who visited the Institute. They were also provided with relevant literature and audiovisual materials. Based on the needs and resources proper guidance was given to coconut growers on planning of coconut based farming systems.

3.2 Coconut mite management programme

With the spread of coconut mite infestation to new areas, the Institute gave high priority to manage coconut mite with the application of burnt engine oil mixture to affected nuts. The division was entrusted with the responsibility of promoting this new technology in all coconut growing areas. A collaborative programme was implemented with the regional staff of CCB. A series of seminars and field demonstrations were conducted for CCB officers to introduce and promote the application of burnt engine oil as a remedial measure.

An educational video documentary was produced on the identification and control of coconut mite. This documentary was telecast over Rupavahini and ITN on several occasions for the benefit of coconut growers and the general public. The documentary was also issued to each Coconut Development Officer in the form of CD to be used in their farmer educational programmes.

Several training programmes were conducted to train coconut tree climbers in different regions on the application of burnt engine oil. A new advisory circular on coconut mite management was published in three languages and issued to all coconut growing areas through the regional staff of CCB. Two colour handouts were issued on the preparation and application of burnt engine oil mixture

and on cultural measures to be adopted to improve the palm vigor. A collaborative programme was implemented to assess the intensity of mite infestation and the level of spread to other areas.

4. TECHNOLOGY TRANSFER AND EDUCATIONAL PROGRAMMES

During the year, the following educational programmes were conducted for the benefit of coconut growers.

No	Participants	No of Participants	Date
1.	A group of coconut growers from Matara area	32	11 February
2.	A group of coconut growers from Kurunegala	30	17 February
3.	A group of coconut growers from Arachchikattuwa	28	16 June
4.	A group of coconut growers from the Agromart Foundation, Chilaw	40	04 July
5.	A group of coconut growers from Badulla area	45	27 July
6	A group of coconut growers from the Agromart Foundation	50	14 September
7.	A group of coconut growers from Kalutara	53	20 September
8.	A group of coconut growers from Akuressa	31	26 October

5. SEMINARS, FIELD DAYS AND WORKSHOPS

5.1 Seminars and workshops

5.1.1 A full day workshop was conducted on 10 January for the members of the Coconut Growers Association of Sri Lanka on the cultivation of Gliricidia in coconut lands and the method of using it as a source of bio-energy. Nearly 200 coconut growers participated in the field demonstrations conducted at CRI substations at Pallama, Ratmalagara and Kohomba Estate.

5.1.2 A full day seminar and workshop was conducted on 16 August at CRI for the CCB regional staff of Marawila, Kuliyapitiya, Kurunegala and Gampaha on the application of burnt engine oil to manage coconut mite.

5.1.3 A presentation on the control of coconut mite was made for the Agricultural Committee Members at the District Secretary's office at Aunuradapura on 19 October.

5.1.4 Demonstrations were conducted for selected coconut pickers on the application of burnt engine oil to control coconut mite at Kurunegala, Anuradapura, Divulapitiya, and Gampaha on 15 November, 19 October, 18 November, and 19 November respectively.

5.1.5 A full day seminar and workshop on the management of coconut pest was conducted on 12 November for the members of the Coconut Growers Association of Sri Lanka.

5.1.6 A seminar and workshop was conducted on 30 November coconut-based products at the Divisional Secretary's Office, Mirigama. The Western Province Industrial Development Authority organized this seminar and workshop.

5.1.7 A seminar was conducted on 16 December at CRI for the CCB staff on the proposed Island wide mite management programme.

5.1.8 A workshop was conducted at Panadura on 21 December on coconut-based products organized by the Western Province Industrial Development Authority.

6. EDUCATIONAL PROGRAMME

6.1 Educational programmes were conducted for science undergraduates from the University of Kelaniya, University of Wayamba and University of Colombo on 14 July, 24 May and 30 January respectively.

6.2 A full day programme was conducted on 25 June on coconut cultivation technologies for a group of school teachers from Maho.

6.3 A full day educational progrmmes was conducted on 05 August for the diploma students of the Agricultural School, Wariyapola.

6.4 An educational programme was conducted on 30 November for the science undergraduates from the University of Jaffna.

6.5 A group of student from the Agricultural School from Agunakolapelessa attended a full day educational programme on coconut cultivation technologies on 07 December.

6.6 An educational programme was conducted for students and the staff of Advanced Technical Institute, Naiwala.

6.7 Two groups of Samurdi Officers from Dambulla attended full day educational programmes on 31 August and 14 September respectively.

6.8 Educational programmes were conducted on 07 August and 04 September for two groups of staff members of CCB Head Office.

6.9 Over seventy-five programmes were conducted for nearly 6500 students in groups who visited the Institute from different areas of the country.

6.10 An educational programme was conducted on 11 August on coconut mite management activities for the entire staff of the Institute.

7. ADVISORY AND CONSULTANCY ACTIVITIES

7.1 Advisory Field Visits

During the year an increasing interest among coconut growers to uplift the productivity of coconut estates was observed. On the request of coconut growers, the staff of the Division provided technical advice and guidance to nearly 30 medium and large coconut estates on plantation development and rehabilitation. Based on the observations and discussions made with the owners during the visit, comprehensive reports were submitted.

7.2 Office Call for Advice

A considerable increase was observed in the number of coconut growers who visited the Division for technical assistance. Special arrangements were made to assist and advise those visitors and provide them with necessary literature and audiovisual materials.

7.3 Technical Advise on Telephone

Coconut growers and other stakeholders extensively use the telephone line available in the Division to obtain technical advice and information. During the year a considerable increase was observed in the number of stakeholders who received services through the telephone.

7.4 Advice through mail

The number of letters received for technical advice and information has increased remarkably during the year and these were replied promptly with relevant information and literature.

8. PRINTING AND PUBLICATIONS

The facilities of the Printing Section of the Division were further improved with the purchase of a modern Digital Duplicator. The Printing Section of the Division achieved a significant progress in respect of the number of printing jobs covered. The Printing Section completed over 45 printing jobs of other Divisions of the Institute.

8.1. The following publications were issued during the year

8.1.1 The journal of the Coconut Research Institute, COCOS vol. 15 and vol. 16 .

8.1.2 Two issues of the proceedings of the International Conference, 75th Anniversary of CRI.

8.1.3 Bibliography on Staff Publications of the Coconut Research Institute 1929- 2004.

8.1.4 Abstract of research papers presented at the research conference held on 08 and 09 September, at Trans Asia Hotel.

8.1.5 Technical bulletins on Coconut Pests and Diseases and Intercropping under coconut.

8.1.6 A booklet on Gliricidia cultivation in coconut lands.

8.1.7 Annual Report for 2003 of the Institute for the Parliament.

8.1.8 Report of the Coconut Research Institute, 2002.

8.1.9 Corporate Plan of the Institute.

8.1.10 A new publication with a title "Coconut Technology Update" was introduced with an attractive colour format in three languages to be published in every four months. The objective of this new publication was to transfer latest technical information to extension personnel and other stakeholders at regular intervals. Three issues of Coconut Technology Update were published in three languages and sold to growers with an annual subscription of Rs. 100/=.

8.1.11 Two colour handouts on the preparation and application of burnt engine oil and on recommended cultural measures on the improvement of palm vigor were issued for the distribution among coconut growers through CCB.

8.2 The following Advisory Circulars were printed and issued

1. Inorganic fertilizer recommendation
2. Nursery management
3. Coconut caterpillar and its control
4. Planting of coconut
5. Application of burnt engine oil for mite control
6. Plesispa beetle in coconut
7. Organic manure for coconut
8. Black Beetle control
9. Red Weevil control
10. Coconut mite management
11. Recommended measures to improve the palm vigor for mite control

Advisory Circulars were posted to coconut growers, students and other stakeholders on their requests.

9. EXHIBITIONS AND AUDIO VISUAL MATERIALS

9.1 The Institute participated in the following exhibitions during the year

1. Techno – Lanka Exhibition at Kuliyapitiya from 14 to 18 January.
2. Exhibition at Kuliyapitiya, Madeena National School, 15 to 17 February
3. Agricultural Exhibition at Loyola College, Negombo, from 17 to 19 June.
4. Field day and exhibition at the Bopitiya Estate from 14 to 16 October.
5. Agricultural exhibition at Morawaka from 10 to 12 December.
6. Mahapola Exhibition at Wennappuwa. From 16 to 22 December.

9.2 Audiovisual materials prepared

1. For the first time in the history of CRI a series of video documentaries on recommended practices for the benefit of coconut growers were produced. These educational documentaries were produced in simple format to provide an understanding on recommended practices of the Institute. The production of the following documentaries was completed and copies were available in CDs at the cost of Rs. 100 per copy.

    a. Coconut mite management
    b. Red Weevil control
    c. Irrigation of coconut

    In addition the video filming works of the following three documentaries was also completed

    a. Coconut Caterpillar control
    b. Intercropping under coconut
    c. Animal Husbandry in coconut estates

2. Ten 30-second video spots were produced on selected technical areas for telecast in order to create interest among the growers.

3. A 23-minute video documentary was produced both in Sinhala and English to highlight the activities of the Institute.

4. Three light boxes and seven digital colour posters were produced for the museum and exhibitions

10. PUBLICITY AND MASS MEDIA PROGRAMMES

10.1 Television Programmes

1. The documentary on Coconut Mite Control was telecast on Rupawahini on 27 August for the benefit of coconut growers.
2. The video documentary produced by the division covering the activities and progress of the Institute during the last 75 years was telecast over Rupavahini on 08 September.
3. The coconut mite control documentary was telecast over ITN on 28 November between 9.10 pm – 9.40 pm and the same programme was again telecast on Rupavahini on 08 December with few trailers.

10.2. Radio Programmes

1. "Gami Sarani" live radio programme was broadcast on 15 November from Kuliyapitiya Divisional Secretaries Office with the participation of the Hon Minister of Plantation Industries and coconut growers in the area. CRI sponsored the programme.
2. CRI sponsored another live radio programme of Gami Sarani which was broadcast from the Divisional Secretary's office at Hambantota.
3. A weekly radio programme " Kupruka Pamula" was commenced in the year with the objectives of educating coconut growers, processors, students and the general public on coconut cultivation, processing, marketing and consumption. This programme was conducted in collaboration with CCB and CDA. During the year, 24 programmes were broadcast over Commercial Service of SLBC.

10.3. Newspaper Articles and Advertisements

During the year twelve news paper articles written by the staff of the Division were published on current issues of the sector. Five newspaper advertisements were published on special events of the Institute.

11. RESEARCH AND SURVEYS

1. A study was conducted in the Kuliyapitiya Region to assess the knowledge level and factors affecting the adoption of control measures of Red Weevil in the small holder sector. The paper written on this study was published in the proceedings of the Research Conference held on 08 September at Trans Asia Hotel in Colombo.

2. A study also conducted in the Kuliyapitiya Region to assess the present situation and constraints of coconut small holders. The paper written on this study was also published in the proceedings of the Research Conference held on 08 September at Trans Asia Hotel in Colombo.

3. The Divisional staff participated in planning and implementation of two surveys, Diagnostic Survey and Leaf Scorch Decline, in the coconut triangle.

REPORT OF THE LIBRARY
Asst. Librarian - P D U C Dharmapala

Services

Reference lending and interlibrary loan services were provided to the staff. The total number of requests received from the outside libraries for ILL was 25 out of which 18 were supplied. Out of 21 request for ILL made by the library from outside resources on behalf of the staff 15 were received.

In addition reference services were made available to outsiders (students, scientists) on request.

External services

The library continued to be an active member of the Agricultural Information Network (AGRINET) with a view to sharing of resources.

The Asst. Librarian participated at 3 AGRINET meetings during the year held at the Council for Agricultural Research Policy (CARP) for the promotions of AGRINET services.

Literature searches were made on the coconut database to cater to the information needs of staff as well as outsiders.

REPORT OF THE ESTATE MANAGEMENT DIVISION
Acting Manager(Estate) – H A J Gunathilaka, Ph D (Wales)

1. GENERAL

The following Research Centres and Genetic Resource Centres were maintained by the Division.

1. Ambakelle Genetic Resource Centre, Ambekelle.

2. Bandirippuwa Main Research Centre, Lunuwila.

3. Dunkannawa Research Centre, Nattandiya.

4. Makandura Genetic Resource Centre, Gonawila.

5. Maduruoya Genetic Resource Centre, Bogaswewa.

6. Pallama Genetic Resource Centre ,Pallama.

7. Poththukulama Research Centre, Pallama.

8. Ratmalagara Research Centre, Panirendawa.

9. Walpita Research Centre, Walpita

All units were maintained in order. An overall increase of 08% in the production of coconuts in all the Centres was observed, compared to the last year.

The average overall COP & NSA in all 09 Centres were 7.59 and 10.22 respectively.

Three additional tables were added in the appendix to elucidate the different components of the income of the centres in response to numerous requests, on and off.

Makandura Genetic Resource Centre (MGRC) was vested by the BOI on the 14 January 2004 and de-vested on the 29 April 2004. Henceforth CRI resumed its activities there.

2. PERFORMANCE OF INDIVIDUAL UNITS

2.1 Ambakelle Genetic Resource Centre (AGRC) : Pallama

Superintendent	:	Mr.W.M. Upali Ratnayaka
District	:	Puttlam
Agro-Climatic Zone	:	Intermediate Dry Zone
Extent	:	456.20 ha

Rainfall :

The total rainfall was 1411 mm and 101 wet days, which indicates an increase by 17 % and 08% respectively compared to the last year.

Nut Yield :

Decreased by 0.5% over the last year. (Table – 1)

Livestock :

Herd strength was as follows.

Stud bulls	-	01
Cows	-	14
Calves (female)	-	18
Calves (Male)	-	10
Cart bulls	-	01
Total	-	44

Income :

Coconuts	= Rs. 15,203,268.64
Copra	= Rs. 1,011,264.96
Animal, Timber, Cashew, etc.	= Rs. 66,590.00
Coconut Shell	= Rs. 30,275.00
TOTAL	= Rs. 16,311,398.60

Cost of Production (COP)

Rs. 6,580.75 for 1000 nuts.

Net Sale Average (NSA)

Rs. 10,962.25 for 1000 nuts.

2.2 Bandirippuwa Main Research Centre (BMRC) : Lunuwila

Superintendent	:	Mr G.B.A.Wijesekara
District	:	Puttlam
Agro-ecological Zone	:	Wet Intermediate
Extent	:	148.1 ha

Rainfall :

The total rainfall was 1726.6 mm and 113 wet days, which registers an increase by 27% and 21% respectively, when compared to the last year. The rainfall distribution was fair.

Nut Yield :

Increased by 23% over the last year.

Livestock :

Cows	-	25
Male calves	-	10
Female calves	-	16
		51

Income :

Coconuts	= Rs. 5,375,832.36
Copra	= Rs. 254,280.80
Milk,treacle,fruit,vegetable & timber etc.	= Rs. 574,112.65
TOTAL	= Rs. 6,214,225.81

Cost of Production (COP)

Rs. 8230.00 per 1000 nuts

Net Sale Average (NSA)

Rs. 8730.00 per 1000 nuts

2.3 Dunkannawa Research Centre (DRC) : Nattandiya

Officer In Charge	:	Mr.Newton Gamage
District	:	Puttalam
Agro-ecological Zone	:	Intermediate Wet Zone
Extent	:	10.4 ha

Rain Fall :

The total rainfall was 1498.9 mm and 115 wet days which shows an increase by 31% & 156% respectively when compared to last year

Nut Yield :

Decreased by 26% over the last year.

Income :

Coconuts		= Rs. 155,616.20
Seedlings		= Rs. 317,085.00
	TOTAL	= Rs. 472,701.20

Cost of production (COP)

Rs. 8,340.00 per 1000 nuts.

Net sale average (NSA)

Rs. 9,270.00 per 1000 nuts.

2.4 Maduruoya Genetic Resource Centre (MOGRC) : Bogaswewa

Acting Superintendent	:	Mr.W.A Harald Upali
District	:	Polonnaruwa
Agro-ecological Zone	:	Dry Zone
Extent	:	85 ha

Rainfall :

Total rainfall received was 1961 mm and 94 wet days which registers an increase by 12% and a by 06% respectively when compared to the last year. The rainfall distribution was better.

Nut Yield :

Increased by 27% over the previous year.

Livestock :

Stud Bulls	-	02
Male buffaloes	-	06
Female buffaloes	-	04
Total	-	12

Income :

Coconuts	= Rs. 920,006.50
Copra	= Rs. 65,387.00
Seedlings	= Rs 188,600.00
Seed nuts	= Rs 3,219,738.13
Fruit,Timber etc.	= Rs. 12,431.00
TOTAL	= Rs 4,406,163.63

Cultural Practices:

The use of buffaloes to control weeds was successful.

Cost of Production (COP)

Rs. 7812.00 for 1000 nuts.

Net Sale Average (NSA)

Rs. 10550.00 for 1000 nuts.

2.5 Makandura Genetic Resource Centre (MKGRC) : Gonawila

Superintendent	:	Mr.A.N.Ekneligoda
District	:	Kurunagala
Agro-ecological Zone	:	Wet Intermediate
Extent	:	58.20 ha

Rainfall :

The total rainfall was 1087 mm and 53 wet days.

Nut Yield :

There is a decrease by 28% over the last year due to the fact that the second pick being not taken into account.

Livestock :

Cows	-	11
Heifers	-	26
Cart bulls	-	10
Calves	-	10
Buffaloes	-	01
Total	-	58

Income :

Coconuts	= Rs. 3,216,868.00
Copra	= Rs 67,236.00
Husks & shell	= Rs. 51,000.00
TOTAL	= Rs 3,335,104.00

Cost of Production (COP)

Rs. 8,340.00 for 1000 nuts.

Net Sale Average (NSA)

Rs. 9,270.00 for 1000 nuts.

2.6 Pallama Genetic Resource Centre (PGRC) : Pallama

Officer In Charge	:	Mr.A.Sugathadasa
District	:	Kurunagala
Agro-ecological Zone	:	Dry Zone
Extent	:	260 ha

Rainfall :

Total rainfall was 1447.2 mm and 74 wet days which registers a decrease by 09% and a decrease by 03% respectively when compared to the last year.

Nut Yield :

Increased by 22% over the previous year.

Livestock :

Cows	-	28
Calves (male)	-	05
Calves (female)	-	09
Stud bulls	-	01
Total	-	43

Income :

Coconuts	= Rs. 5,842,513.28
Copra	= Rs. 172,352.50
Fruit,Milk etc.	= Rs. 103,267.34
TOTAL	= Rs. 6,118,133.12

Cost of Production : (COP)

Rs. 7660.00 per 1000 nuts.

Net Sale Average (NSA)

Rs. 1054.00 per 1000 nuts.

2.7 Poththukulama Research Centre (PRC) : Pallama

Officer In Charge	:	Mr.D.L.J.Nethasinghe
District	:	Puttlam
Agro-ecological Zone	:	Intermediate Dry Zone
Extent	:	74.28 ha

Rainfall :

The total rainfall received was 1329.89 mm and 77 wet days which registers an increase and a decrease by 06% and 10% respectively when compared to the last year.

Nut Yield :

Increased by 15% over the previous year.

Livestock :

Cows	-	16
Bulls	-	52
Goats (male)	-	15
Goats (female)	-	63
Buffaloes	-	07
Total	-	153

Income :

Coconut	= Rs. 4,074,357.63
Copra	= Rs. 65,387.00
Seedlings	= Rs. 188,600.00
Fruit,Timber etc.	= Rs. 12,431.00
TOTAL	= Rs. 4,340,775.63

Cost of Production (COP)

Rs. 5,925.78 for 1000 nuts.

Net Sale Average (NSA)

Rs. 9,631.46 per 1000 nuts

2.8 Ratmalagara Research Centre (RRC) : Panirendawa

Superintendent	:	Mr.W.S.M.A.Fernando
District	:	Puttlam
Agro-ecological Zone	:	Intermediate Dry Zone
Extent	:	110.48 ha

Rainfall :

The total rainfall received was 1753.2 mm and 103 wet days which registers an increase by 29% and a decrease by 04% respectively when compared to the last year. The rainfall distribution was fair.

Nut Yield :

Increased by 27% over the previous year.

Livestock :

Female Calves	-	26
Male Calves	-	12
Cows	-	34
Cart bulls	-	01
		73

Income :

Coconut	= Rs. 5,840,106.85
Copra	= Rs. 110,225.50
Seedlings	= Rs. 1,322,225.00
Milk	= Rs. 215,682.88
Fruit	= Rs. 43,897.00
Timber etc.	= Rs. 58,002.00
TOTAL	= Rs. 7,590,139.23

Cost of Production (COP)

Rs. 9500.00 for 1000 nuts.

Net Sale Average (NSA)

Rs. 11,250.00 for 1000 nuts.

2.9 Walpita Research Centre (WRC) : Walpita

Officer In Charge	:	Mr.I.A.Nimal Hemasiri
District	:	Gampaha
Agro-ecological Zone	:	Wet Intermediate
Extent	:	17.8 ha

Rainfall :

Total rainfall was 2400.02 mm and 119 wet days which indicate an increase by 09% and a decrease by 21% respectively, when compared to the last year..

Nut Yield :

Indicates a slight decrease of 0.05% over the last year.

Livestock :

Cows	-	02
Cart Bulls	-	01
Total	-	03

Income :

Coconuts	= Rs. 1,289,624.46
Seedlings	= Rs. 113,610.00
Fruit and Spices	= Rs. 187,728.38
TOTAL	= Rs. 1,590,962.84

Cost of Production (COP)

Rs. 9,550.00 for 1000 nuts.

Net Sale Average (NSA)

Rs. 10,210.00 for 1000 nuts.

Table 1. *Total Nut production (2000 – 2004) and percentage Change in 2004 production over 2003*

Centre	2000	2001	2002	2003	2004	% change
Bandirippuwa Main Research Centre	758,487	752,452	319,296	540,072	664,511	+ 23
Ambakelle Genetic Resource Centre	1,396,565	1,475,761	662,854	1,549,281	1,541,739	
Poththukulama Research Centre	834,061	777,906	440,222	687,763	786,142	+ 15
Ratmalagara Research Centre	658,968	760,946	405,305	533,073	674,932	+ 27
Pallama Genetic Resource Centre	640,343	680,946	354,060	509,925,	618,934	+ 22
Makandura Genetic Resource Centre	644,016	636,889	286,187	477,697	320,509	+ 33
Maduruoya Genetic Resource Centre	297,328	346,507	344,623	309,106,	392,185	+ 27
Walpita Research Centre	188,958	160,124	129,473	126,927	126,278	
Dunkannawa Research Centre	-	-	7,940	17,614	12,987	- 26
Total	5,418,716	5,591,431	2,949,960	4,211,391	4,519,283	+ 08

Table 2. *Rain fall (mm) and Number of Wet days - (2003 – 2004)*

Month	Bandirippuwa Main Research Centre		Ambakelle Genetic Resource Centre		Ratmalagara Research Centre		Poththukulama Reserch Centre	
	2003	2004	2003	2004	2003	2004	2003	2004
January	54.2(06)	Nil	46.7(08)	Nil	112.2(09)	Nil	44(07)	Nil
February	02(01)	N.A	19.6(04)	25.8(01)	27.8(03)	6.2(01)	23(04)	24.0(01)
March	77(09)	7.2 (01	161.3(10)	11.5(03)	177.8(09)	4.0(02)	168.15(09)	22.09(04)
April	146(10)	72.3(06)	178.6(10)	56.8(10)	125.8(11)	159.9(13)	214.15(07)	77.04(06)
May	168.5(08)	133.4(16)	71(07)	319.2(11)	138.3(04)	207.3(14)	55.5(04)	197.10(09)
June	214.9(11)	170.7(12	162(13)	93.1(10)	264.3(16)	109.4(12)	148.2(11)	97.28(09)
July	69.8(09)	131.4(08)	94.9(09)	84.9(05)	48(11)	90.0(06)	122.7(09)	95.07(04)
August	17.1(04)	71.1(05)	14.5(01)	11.4(02)	5.4(02)	46.2(03)	7.5(02)	12.06(02)
September	81.9(04)	253.4(19)	23.5(03)	128.0(16)	26.5(05)	198.5(10)	24.2(06)	75.20(09)
October	293(17)	448.5(21)	217.4(13)	229.1(15)	251.9(21)	301.5(19)	178.19(15)	197.23(13)
November	234(15)	331.3(16)	199.6(12)	340.3(17)	168.7(15)	528.5(17)	252.9(11)	416.22(12)
December	-	104.3(09)	22.3(04)	110.9(11)	16.6(02)	101.7(06)	23(01)	116.6(08)
Total	1360.5(94)	1723.6(113)	1211.4(94)	1411(101)	1363.3(108)	1753.2(103)	1261.31(86)	1329.87(77)

Continued Table – 02

Month	Pallama Genetic Resource Centre		Makandura Genetic Resource Centre		Maduruoya Genetic Resource Centre		Walpita Research Centre		Dunkanawa Research Centre	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
January	38.4(03	Nil	90.4(06)	Nil	358(12)	206.9(07)	164(05)	Nil	59(03)	Nil
February	20.1(03)	72.0(01)	10.6(01)	N.A	257.2(09)	45.5(04)	21(01)	45.2(02)	-	-
March	189.8(07)	6.0(01)	191.1(11)	N.A	88.9(07)	104.1(04)	265.2(13)	126.3(05)	118.6(05)	31.6(02)
April	215.3(10)	138.4(09)	196.4(13)	N.A	63.7(06)	41.7(04)	284.2(09)	156(08)	142.5(05)	164(08)
May	114.6(04)	276.5(07)	169.8(09)	N.A	82.3(05)	60.5(05)	140.5(07)	284.4(20)	61.4(02)	160.9(19)
June	187(12)	109.5(07)	220.9(15)	N.A	26.2(02)	N.A	251(11)	184.1(10)	252.4(07)	109.2(10)
July	49.6(06)	93.6(05)	130(09)	69.0(01)	64.0(04)	38.7(04)	251.2(11)	196(09)	118.8(04)	106.8(07)
August	48.6(06)	10.9(02)	64.5(06)	82.2(04)	27.1(02)	35(03)	142.8(13)	81.5(05)	4(01)	31.3(04)
September	10(03)	660.0(10)	97.5(08)	277.9(11)	-	123(09)	75(05)	419.9(15)	11.8(01)	192(18)
October	223.7(13)	208.8(07)	-	303.3(17)	114.7(08)	382.4(17)	382(15)	410(19)	255.8(13)	326.5(23)
November	206.3(10)	326.9(16)	-	226.6(13)	521.9(23)	416.8(22)	240(09)	360.3(18)	121.5(04)	279.5(18)
December	22.2(04)	138.6(09)	-	128.2(07)	156.9(11)	506.4(15)	-	135.8(08)	-	97.1(06)
Total	1325.6(76)	1447.2(74)		1087.2(53)	1760(89)	1961(94)	2217.4(99)	2,400.2	1145.5(45)	1,498.9(115)

(N.A = Not Available)

Table 3. *Coconut Extent and Census of palms*

Estate	Bandirippuwa Main Research Centre	Ratmalagara Research Centre	Ambakelle Genetic Resource Centre	Maduruoya Genetic Resource Centre	Poththukulama Research Centre	Walpita Research Centre	Makandura Genetic Resource Centre	Pallama Genetic Resource Centre	Dunkaannawa Research Centre	Total
Extent (ha)	148.1	110.5	456.20	85	74.3	17.8	58.2	260	10.4	899.67
Bearing palms	11,668	12,587	17,875	5,531	10,491	1,815	4,822	10,190	326	75,305
Partial bearing palms upto 10 years	425	543	1,439	1,403	46	06	265	97	-	4,224
Young palms 2 years upto bearing	567	953	951	891	178	-	-	5,570	-	9,110
Seedlings upto 2 years	979	526	39	1,429	255	-	64	4,701	834	8,827
Weak palms	908	105	242	1,075	446	163	3,024	1,210	03	9,176
Vacancies	3,925	1,490	5,726	3,843	2,060	582	2,051	2,456	05	22,138
Planting Points	18,472	16,204	26,272	14,172	13,476	2,566	10,222	24,224	1,168	126,776

Table 4. *Physical Extent of Estates and Seed Garden (Extent – ha)*

Extent	Bandirippuwa Main Research Centre	Ratmalagara Research Centre	Ambakelle Genetic Resource Centre	Maduruoya Genetic Resource Centre	Poththukulama Research Centrre	Walpita Research Centre	Makandura Genetic Resource Centre	Pallama Genetic Resource Centre	Dunkannawa Research Centre	Total
Mature (ha)	113	98	120.8	35.0	74.28	15.5	52.8	188.0	2. 0	699.60
Immature (ha)	21.0	26.0	12.5	44.0	05.00	-	1.0	176.0	5. 6	291.10
Total coconut extent	134	124	133.3	79.0	79. 28	15.5	53.8	364.0	7. 6	990.70
Nursery	1.81	-	1.00	-	-	-	-	-	-	2.61
Other Crops	-	1.00	-	1.0	-	-	-	-	-	2.0
Jungle	-	03.24	322	1.0	-	-	-	29.2	-	338.24
Vacant Land	1.0	05.88	7.1	2.0	1.0	-	-	1.0	3	17.98
Reservation/Tank	-	-	3.0	8.0	-	0.5	2.4	-	0. 2	21.11
Roads & Building	22.25	2.02	3.0	2.00	2.5	1.8	2.0	3.0		38.07
Total	159.06	136.4	602.7	175	82.78	17.8	58.2	397.2	13.2	1410.71

Table 5. *Nut Production in Estates - 2004*

Pick	Bandirippuwa Main Research Centre	Ratmalagara Research Centre	Maduruoya Genetic Resource Centre	Poththukulama Research Centre	Walpita Research Centre	Makandura Genetic Resource Centre	Pallama Genetic Resource Centre	Ambakelle Genetic Resource Centre	Dunkannawa Research Centre	Total
Pick – 1	97,361	127,054	71,793	153,456	29,613	40,071	137,410	318,836	2,798	978,392
Pick – 2	190,873	116,364	40,034	167,835,	28,490	N.A	161,925	480,481	3,694	1,189,696
Pick – 3	171,258	136,826	50,062	171,716	33,678	120,021	102,108	250,701	2,363	1,038,733
Pick – 4	83,771	105,606	52,990	118,200	23,546	78,157	87,045	205,273	2,104	756,692
Pick - 5	82,210	78,066	38,797	107,067	7,916	55,516	84,854	180,951	1,408	636,785
Pick – 6	39,038	111,016	57,206	67,868	3,035	26,744	45,592	105,497	620	456,616
Pick - 7	Nil	Nil	81,303	Nil	Nil	Nil	Nil	Nil	Nil	81,303
Total	664,511	674,932	392,185	786,142	126,278	320,509	618,934	1,541,739	12,987	5,138,217

Table 6. *Crop Disposal COP and NSA – 2004*

Particulars	Bandirippuwa Main Research Centre	Ratmalagara Research Centre	Maduruoya Genetic Resource Centre	Poththukulama Research Centre	Walpita Research Centre	Makandura Genetic Resource Centre	Pallama Genetic Resource Centre	Dunkannawa Research Centre	Ambakelle Genetic Resource Centre
Sold	523,615	526,8 03	143,442	697,308	111,652	281,618	387,488	11,087	395,230
Copra	56,918	12,980	15,869	39,845	7,410	17,121	29,883	Nil	
Research	3,894	Nil	Nil	3,253	Nil	Nil	1,720	Nil	1,465
Seed Nut		Nil	213,920	3,515	Nil	Nil	Nil	Nil	831,069
Staff Issue	57,997	6,272	1,415	4,515	1,537	2,897	4,192	1,176	7,421
Rejections		16,155	11,039	21,019	2,760	11,152	20,363	Nil	
Destroyed	18,188	Nil	Nil	Nil	Nil	Nil	Nil	272	32,676
Awaiting Disposal	Nil	Nil	Nil	Nil	Nil	Nil	Nil	452	69,403
Nursery	Nil	Nil	6,500	Nil	Nil	Nil	Nil	Nil	13,266
Others	3,899	Nil	Nil	1,000	2,799	7,721	Nil	Nil	
Total Nos of Nuts	664,511	549,230	392,185	770,455	126,158	320,509	443,646	12,987	1,350,530
COP (RS)	8.23	9.50	7.81	5.92	9.55	4.73	7.66	8.34	6.58
NSA (RS)	8.73	11.25	10.55	9.63	10.21	10.88	10.54	9.27	10.96

Table 7. *Total Seed Nut Production*

Centre	2003	2004	Change %
1. Ambakelle Genetic Resource Centre	964,441	831,069	- 13
2. Maduruoya Genetic Resource Centre	129,890	213,920	+ 65
3. Ratmalagara Research Centre	Nil	26,220	-
4. Pallama Genetic Resource Centre	8,735	5,780	-33
5. Dunkannawa Research Centre	Nil	5,280	-
Total	1,103,066	1,082,269	- 1.00

Table 8. *Income from Fresh Coconuts - 2004*

Centre	Income (Rs)
Ambakelle G.R.C	15,203,267.77
Bandirippuwa M.R.C	5,385,832.36
Dunkannawa R.C	155,616.20
Maduruoya G.R.C	4,074,357.63
Makandura G.R.C	3,216,868.00
Pallama G.R.C	5,842,513.28
Poththukulama R.C	7,094,683.81
Ratmalagara R.C	5,840,106.85
Walpita R.C	1,255,780.46
Total	48,069,026.22

Table 9. Income From Coconut Seedlings - 2004

Centre	Income (Rs)
Ambakelle G.R.C	398,140.00
Maduruoya G.R.C	188,600.00
Ratmalagara R.C	1,322,225.00
Dunkannawa R.C	317,085.00
Walpita R.C	113,610.00
TOTAL	2,339,660.00

Table 10. Income from allied coconut products (Copra,Shell,Husks,etc) - 2004

Centre	Income (Rs)
Ambakelle G.R.C	1,011,264.96
Bandirippuwa M.R.C	254,280.80
Dunkannawa R.C	NIL
Maduruoya G.R.C	65,387.00
Makandura G.R.C	118,236.00
Pallama G.R.C	172,352.50
Poththukulama R.C	169,889.34
Ratmalagara R.C	110,225.50
Walpita R.C	33,844.00
TOTAL	1,935,480.10

Table 11. Sundry Income (Fruit, Vegetables, Spices, Milk etc.) - 2004

Centre	Income (Rs)
Ambakelle G.R.C	288,261.14
Bandirippuwa M.R.C	574,112.65
Dunkannawa R.C	317,085.00
Maduruoya G.R.C	12,431.00
Makandura G.R.C	62,148.00
Pallama G.R.C	317,085.00
Poththukulama R.C	17,470.00
Ratmalagara R.C	317,581.88
Walpita R.C	187,728.38
TOTAL	1,880,085.39

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 and financial matters and related affairs including maintenance work.

2. CADRE

The staff position of the Coconut Research Institute at the end of December 2004, is given in Table 1:

Table 1. *Staff position as at 31/12/2004*

Grade	Un-graded	Sp C1	C1 I	C1 II	C1 III	C1 IV	Total
Executive	01	-	07	11	19	15	53
Technical	-	35	11	17	-	-	63
Inter mediates	-	05	01	01	-	-	07
Clerical & Allied	-	24	05	06	-	-	35
Operative	-	20	11	13	-	-	44
Driver	-	18	05	06	-	-	29
Minor	-	40	15	19	-	-	74
Watcher	11	-	-	-	-	-	11
Grand Total	12	142	55	73	19	15	316

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 64 employees, amounting to Rs.14,617,600.00

Distress Loans: Granted for 45 employees amounting to Rs.2,958,381.00

Transport Loans: Granted for 26 employees amounting to Rs.1,218,050.00

Refrigerator Loans : Granted for 06 employees amounting to Rs.72,000.00

Loan Relief to Indebtedness Loans : Granted for 03 employees amounting to Rs.22,500.00

Medical Aid: Rs.2,140,450.00 was reimbursed by the Medical Aid Scheme during the year 2004, and an amount of Rs.712,391.00 was distributed to 347 Members Savings Accounts.

The following medical clinics were conducted in the year 2004

- Dental Clinic
- Blood Donation Programme
- Medical Check up for members & their families conducted by Asiri Hospitals (Pvt.) Ltd.
- Conducted lectures about Positive Thinking
- Mosquito Control Programme

3.2 Other facilities to employees

(a) Financial assistance was also granted to the Multi-purpose Co-operative Society, Art Circle, Day Care Centre, Seva Vanitha Movement, Death Donation and the Recreation Club during the year 2004.

STAFF MATTERS

4. APPOINTMENTS

No appointments were given during the year 2004

5. RESIGNATIONS, RETIREMENTS, VACATION OF POSTS & TERMINATIONS OF SERVICES & DEATHS

The details are given in Table 2

Table 2.

Name	Designation	Division/Unit	Date
Resignations:			
Mrs. U G M B K Tennakoon	Research Officer	Soils & Plant Nutrition Division	02.01.04
Mr. H M Manelhamy	Lab/Field Attendant	Estates Management Division	01.03.04
Mr. S P Manoj	Technical Officer	Crop Protection Division	01.11.04
Retirements:			
Mr. Premsiri Silva	Technical Officer(A & V)	Technology Transfer Division	09.02.04
Mr. H P Karanis	Senior Lab/Field Attendant	Estates Management Division	26.03.04
Mr. D M Ratnayake	Senior Garden Labourer	Estates Management Division	15.05.04
Mr. D T Mathes	Head/Biometry Division	Biometry Division	01.07.04
Mr. K L V Fernando	Senior Binder	Library	16.07.04
Mr. M A M Perera	Clerk/Typist	Engineering Unit	20.07.04
Mr. D Kumarapeli	Senior Office Attendant	Library	08.09.04
Mr. K S A J Fernando	Senior Lab/Field Assistant	Soils & Plant Nutrition Division	12.11.04
Mr. K W Piyadasa	Senior Tinker	Engineering Unit	20.11.04
Mr. P A D R G Caldera	Lab/Field Assistant	Crop Protection Division	29.12.04
Vacation of Posts:			
Mr. R P Sugath Rohana	Driver	Establishment Unit	17.01.04
Deaths			
Mr. D M Sarathchandra	Lab/Field Assistant	Genetics & Plant Breeding Division	05.06.04

6. PROMOTIONS

6.1 PROMOTIONS IN NON-EXECUTIVE GRADES

Following Internal Promotions in Non-Executive Grades were implemented during the year 2004, as shown in Table 3. The effective date of these promotions was 01/01/2004.

Table 3. *Promotions in Non-Executive Grades during the year 2004*

Name	Designation	Division/Unit
CLASS 1 TO SPECIAL CLASS		
Technical Grade		
Mrs. C P A Kurundukumbura	Senior Technical Officer	Soils & Plant Nutrition Division
Mr. G K Ekanayaka	Senior Technical Officer	Genetics & Plant Breeding Division
Clerical & Allied Grade		
Mr. Y H Wijesena	Senior Clerk/Typist	Establishment Unit
Operative Grade		
Mr. N G Premasiri	Senior Lab/Field Assistant	Crop Protection Division
Minor Grade		
Mr. S M Subasinghe	Senior Mechanical Helper	Engineering Unit
Mr. P David Perera	Senior Electrician	Engineering Unit
CLASS II TO CLASS I		
Technical Grade		
Mr. K P A Pathirana	Technical Officer	Soils & Plant Nutrition Division
Mr. B S V J Perera	Technical Officer	Soils & Plant Nutrition Division
Clerical Grade		
Mr. K T G N W Perera	Clerk/Typist	Engineering Unit
Operative Grade		
Mr. W W A P R Fernando	Supervisor	Estates Management Division

Minor Grade

Mrs. B A D Kusumawathi	Lab/Field Attendant	Plant Physiology Division
Mr. K J J Appuhamy	Building Helper	Engineering Unit
Mr. N A Wasantha Jayasiri	Lab/Field Attendant	Technology Transfer Division
Mrs. S A Sumanawathi	Lab/Field Attendant	Estates Management Division

6.2 PROMOTIONS IN EXECUTIVE GRADES

Following Promotions in Executive Grades were implemented during the year 2004, as shown in Table 4 & 5

Table 4. *Promotions in Executive Grades during the year 2004*

Executive Grade Class II to Class I

Name	Designation	Division	Effective Date
Dr. N A Tennakoon	Head/Soils & Plant Nutrition Division	Soils & Plant Nutrition Division	10.03.2004
Dr.(Mrs.) W N I S C Fernando	Principal Research Officer	Tissue Culture Division	15.03.2004

Table 5.

Executive Grade Class III to Class II

Name	Designation	Division	Effective Date
Mr. A D Samarajeewa	Senior Research Officer	Agronomy Division	20.09.2003
Dr. J M M M Marikkar	Senior Research Officer	Coconut Processing Research Division	30.09.2004

7. TRANSFERS

Mr J A D H Newil , Tractor Driver, From Genetic Resource Centre Maduruoya to Bandirippuwa Research station on January.01

Mr M Victor, Lab & Field Assistant, From Genetic Resource Centre Makandura to Genetic & Plant Breeding on January 16

Mr M Victor, Lab & Field Assistant, From Genetics & Plant Breeding to Walpita Research Centre on August 01

Mr K K Piyathissa, Tractor Driver, From Genetic Resource Centre Makandura to Genetic Resource Centre Maduruoya on January 10

Mr K K Piyathissa, Tractor Driver, From Genetic Resource Centre Maduruoya to Genetic Resource Centre Makandura on May 16

Mr U A R F Calister watcher, Genetic Resource Centre Makandura to Banddirippuwa Research Station January 16

Mr U A R F Calister watcher, From Banddirippuwa Research Station to Genetic Resource Centre Makandura on June 01

Mr M P S Abyathissa , Lab & Field Attendant, From Genetic Resource Centre Makandura to Bandirippuwa Research Station on January 16

Mr M P S Abyathissa , Lab & Field Attendant, From Bandirippuwa Research Station to Genetic Resource Centre Makandura on April 29

Mr A C Pradeep Supervisor , from Genetic Resource Centre Makandura to Genetic Resource Centre Pallama on January 16

Mr W M D R Wijesinghe, Supervisor, From Genetic Resource Centre Maduruoya to Genetic Resource Centre Ambakelle on April 06

Mr M G D D Plasidez , Supervisor From Genetic Resource Centre Pallama to Poththukulama Research Station on January 01

Mr W M N G Wijethunga , Supervisor ,From Poththukulama Research Station to Genetic Resource Centre Maduruoya on June 07

Mr W M N G Wijethunga , Supervisor ,from Genetic Resource Centre Maduruoya to Genetic Resource Centre Ambakelle on October 01

Mr J A D N Stanly, Polination Labourer From Genetic Resource Centre Pallama to Genetic Resource Centre Ambakelle on March.01

Mr K G Danapala , Lab & Field Attendant From Walpita Research Centre, to Genetic Resource Centre Makandura on June 21

Mr M Somasiri , Clerk Typist, From Accounts Unit to Engineering Unit on July 01

Mr M A Sunil Fernando, Supervisor From Genetic Resource Centre Ambakelle to Poththukulama Research Station on July 05

Mr E M A Thilkartna Banda , Technical Assistant From Soils & Plant Nutrition Division to Rathmalagra Research Centre on June 04

Mr A N Eknaligoda, Superintendent From Genetic Resource Centre Makandura to Estates Management Division on January 16

Mr A N Eknaligoda , Superintend From Estates Management Division to Genetic Resource Centre Makandura on April 29

Mr W C M Fernando, Tractor Driver, From Dunkannawa Research Station to Poththukulama Research Station on November 01

Mr W C M Fernando Tractor Driver, From Poththukulama Research Station to Bandirippuwa Research Station December 01

Mr H G Wasantha Technical Assistant From Agronomy Division to Middeniya Farm on November 01

8. OVERSEAS STUDY LEAVE

Table 6. *Full pay leave in overseas*

Name	Designation	Period	Purpose	Institute
Mrs. D M D I Wijebandara	Soil Scientist	18/10/2004 - 18/10/2007	Postgraduate Training to Ph.D.	University of Agricultural Science, Dharwad, India

9. LOCAL STUDY LEAVE

Table 7.

Name	Designation	Period	Purpose	Institute
Mr. A R Kulatunga	Technical Assistant	04 years	A course of training leading to B.I.S.	Open University
Mr. R P B S H S Senarathne	Agronomist	03 years	Postgraduate training Ph.D.	Postgraduate Institute of Agriculture Peradeniya

10. SABBATICAL LEAVE

Table 8.

Name	Designation	Period	Purpose	Institute
Dr. H A J Gunathilaka	Head/Agronomy Division	01 year	Sabbatical Leave	Coconut Cultivation Board

11. LOCAL TRAININGS / WORKSHOPS

Mr. J D J S Kularatne/Senior Technical Officer followed a certificate Course on GIS and GEO Informatics at the Postgraduate Institute of Agriculture, University of Peradeniya from 26 – 31 January.

Mr. S Wickramarachchi/Technical Assistant followed a training course on HTML and Dream Weaver at IDM Software International (Pvt.) Ltd. From 19-24 January.

Mrs. P I P Perera/Botanist followed a training in techniques of Molecular Biology in Postgraduate Institute of Agriculture, University of Peradeniya from 01-13 March.

Mr. L M S R Jayatillake is attending the six-month (part time) course offered by SLIDA on Diploma in Information Technology from 6 June 2004.

Mr. C S Herath/Extension Officer, Mr. J K J P Jayawardena/Asst. Extension Officer, Mr. W A S Wickrarachchi/Technical Assistant, Mr. Roshan Jayathilaka/Senior Technical Officer followed Diploma course in Information Technology at Sri Lanka Institute of Development Administration 06 months from 6 July (Every Sunday).

Dr. N A Tennakoon and Mrs. D M D I Wijebandara participated at a Symposium on Plantation Crop Research held in BMICH, Colombo, Sri Lanka, 8-9 July, 2004.

Mr. M R D Perera/Technical Officer followed a certificate course on GIS and GEO Informatics in Postgraduate Institute of Agriculture from 9-14 August.

Mr. M R D Perera participated in a training programme on Certificate Course on GIS and Geo-Informatics held in Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka from 9 to 14 August, 2004.

Mrs. N Wijesinghe/Accounts Clerk, Mr. M R U Attanayake, Mrs. A A N P Kanthi followed a training programme for Accounts Clerks at the Institute of Government Accounts & Finance from 16-20 August.

Dr. A Nainanayake, Senior Research Officer, Plant Physiology Division, attended a three-day workshop on use of molecular techniques at the Dept. of Export Agriculture, Matale from 30 August to 01 September.

Dr. N A Tennakoon, Mrs. D M D I Wijebandara, Mr. G D George, Mrs. S Sabaratnam, Mrs. N H R M de Silva, Mr. U S S Perera, Mrs. S D H Bandara, Mrs. C P A Kurundukumbura, Mrs. H L A P Liyanage Mr. K P A Pathirana, and Mrs. H M A Herath participated in the International Conference of the 75th Anniversary of Coconut Research Institute held in Trans Asia Hotel, Colombo, Sri Lanka, 8-10 September, 2004.

Mr. H M N B Herath/Technical Officer, Mr. G R A Dharmasena/Technical Officer followed a training course on Electronics and Nuclear Instrumentation at Atomic Energy Authority Colombo from 13 September – 04 October.

Mr. H M N B Herath attended a training course on Electronics and Nuclear Instrumentation at the Atomic Energy Authority from 13 September to 4 October 2004.

Dr. N A Tennakoon and Mr. M R D Perera participated at a workshop on " The Water Professionals Day" held in Postgraduate Institute of Agriculture, Peradeniya, Sri Lanka on 1 October, 2004.

Mr. B M D Bandara/Chief Clerk, Mr. W A C Fernando/Book Keeper, Mrs. N Wijesinghe/Accounts Clerk, Mrs. Dasy Dias/Senior Typist, Mr. A S Nanayakkara/Senior Accounting Assistant followed a certificate course in English Language at University of Colombo - 06 months from 6 November 2004 (one day per week).

Mr. S S Rajapaksa/Technical Officer followed a training on Implementing Networks Using Cisco Routers and Local Network Administrator at Sri Lanka Telecom Ltd. From 22 November to 03 December.

12. OVERSEAS VISITS

Dr.(Mrs.) L C P Fernando/Head/Crop Protection Division participated in the inception meeting of the CFC/APCC/FAO project on Integrated Pest Management of Coconut mite and Oryctes beetle Bogor, Indonesia from 21 to 25 January.

Mr. A D Samarajeewa/Agronomist visited the project sites of the project on "Poverty Reduction in Coconut Growing Communities" in Bangladesh from 23-29 April.

Dr. L Perera delivered a lecture on invitation in the International symposium on coconut and oil palm biotechnology from 18 -20 April 2004 in the Philippines.

Mr. A D Samarajeewa/Agronomist attended the programme progress review meeting of the A D B funded project, "Poverty reduction in coconut growing communities" in Vietnam from 27-30 September.

Mrs. S R Samarajeewa/Senior Agricultural Economist attended the programe progress review meeting of the ADB funded project, "Poverty reduction in coconut growing communities" in Vietnam from 27-30 September.

Dr. T S G Peiris/Principal Biometrician attended the Second Asia and the Pacific Regional workshop on Assessments of Impacts and Adaptations to Climate Change (AIACC) and visit to Philippine Coconut Authority (PCA) in Philippines from 01-10 November.

Dr.(Mrs) C Jayasekara/Director attended CFC Funded project meeting and 13th COGENT Steering Committee Meeting in Malaysia from 16-25 November.

Dr. (Mrs) L C P Fernando/Head/Crop Protection Division attended the first meeting of the CFC/APCC/FAO Project on Coconut mite to present progress and next year's work plan in Philippines from 29-November to 01 December.

13. OVERSEAS TRAININGS

Dr. H A J Gunathilaka/Head/Agronomy Division, followed a training in Agricultural Research Management for Scientists at NAARM Hyderabad, India from 02-21 February.

Dr.(Mrs.) C S Ranasinghe/Head, Plant Physiology Division followed a training on Developing Dynamic Crop Models for Coconut under the UNEP/GEF project at the Indian Agricultural Research Institute, New Delhi from 22 February – 05 March.

Mr. G R A Dharmasena /Technical Officer followed a International Course on New Technology of Agricultural Engineering at the Chinese Academy of Agricultural Machinery Science (CAAMS), China from 07-27 April.

Dr.(Mrs.) L K Weerakoon/ Head/Tissue Culture Division followed a symposium on the application of biotechnology to coconut and oil palm improvement and a laboratory course on biotechnology and bio informatics at Albay Research Centre, Philippines 18 April – 01 May.

Dr. A A F L K Perera/Senior Geneticist & Plant Breeder followed a International symposium on the application of biotechnology for coconut and oil palm improvement at Albay Research Centre, Philippines 18 – 22 April.

Mrs. W S Madurapperuma, Research Officer, Plant Physiology Division, attended orientation training on using sap flow sensor in Malaysia from 25 to 26 May.

Mrs. H D D Bandupriya/Botanist followed a short-term training on Cryopreservation of Coconut Plumules at IRD station Montpellier Institute for Research and Development, Montpellier France from 01 June – 02 October.

Mr. J M D T Everard attended training on Coconut Genomics at the Max-Planck Institute, Koln Germany from 16 June – 10 July 2004.

Mr. S P Manoj/Technical Officer followed a short term training on Microbiological Techniques in Mass Production of Fungus at CABI Bioscience, United Kingdom from from 04 – 18 July.

Mrs. T R Gunathilaka/Technical Assistant participated at a Coconut Germplasm Collection Programme at MARC, Ivory Coast Delorme International Coconut Gene Bank from 07-30 August.

Dr.(Mrs.) C K Bandaranayaka/Senior Geneticist & Plant Breeder participated at a Coconut Germplasm Collection Programme at MARC, Ivory Coast Delorme International Coconut Gene Bank from 07-30 August.

Mrs. P I P Perera/Botanist followed a Short-term training at the IRD station. Montpellier, Institute for Research and Deveopment (IRD) Montpellier, France from 01 September – 31 November.

Mrs. D C L Hapuarchchi/Senior Technical Officer followed a short term training on molecular pathogen diagnosis & Molecular assay procedures at the Indian Agricultural Research Institute, New Delhi, India from 05 October – 25 October.

Mr. H M N B Herath/Technical Assistant followed a short term training on molecular pathogen diagnosis & Molecular assay procedures at the Indian Agricultural Research Institute, New Delhi, India from 05 October – 25 October.

Mrs. W S Madurapperuma, Research Officer, Plant Physiology Division, pursued a six-month training on adaptation of different woody tree species to water stress condition by cavitation (embolism) and the possibility of using it as a trait to screen for drought tolerance at the University of Western Australia, Australia from 05 October.

Mr. R P B S H S Senarathne/Agronomist participated at the 33rd UNEP/UNESCO/BMU international short course on environmental Management for Developing Countries – Soil Management at University of Dresden, Germany from 18 October – 09 November.

Mr. S H S Senarathna participated in UNEP/UNESCO/BMV International short course on Environmental Management for Developing Countries - Soil management (18 October – 9 November, 2004), University of Dresden, Germany.

Mrs. D M D I Wijebandara, Soil Scientist left for Post Graduate Studies at the University of Dharwad, India sponsored by CARP on 18 October, 2004.

Mrs. M A D W S Madurapperuma/Plant Physiologist followed a short term course in plant physiology, particularly on adaptation of woody tree species to water stress condition by cavitations and the possibibity of using it as a trait to screen for drought tolerant varieties at University of Western, Australia from 28 October 2004 to 28 March 2005.

Mr. N A K de Silva, successfully completed his M Sc degree at Cornell University, USA, under a Full bright Fellowship.

14. PARTICIPATION IN OTHER STATUTORY BOARDS AND COMMITTEES

Mr. J M D T Everard served as Chairman of the National Committee on Plant Breeding and Biotechnology of the Council for Agricultural Research Policy.

Mr. J M D T Everard served in the SLAAS Committee on Popularization of Science as a member in 2004.

Mr. J M D T Everard served as a member of the National Sub Committee appointed by the Ministry of Environment and Natural Resources for development of a national policy for Biotechnology and Biosafety.

Dr. C Banadaranayake served as a member of the National Sub Committee appointed by the Ministry of Environment and Natural Resources on technical and technological aspects for GMO and GMF testing.

Dr. N A Tennakoon served as a member of the working group for standardization of organic fertilizer of Sri Lanka Standards Institute.

Dr. N A Tennakoon served as a member of the Advisory Committee on Fertilizer of the Honorable Minister of Agriculture, Livestock, Land and Irrigation.

15. TRANSPORT UNIT

The Transport Unit did administration of the staff of the unit including drivers and maintenance of the following fleet of vehicles during the year 2004.

Buses	-	03
Lorries	-	02
Vans	-	08
Cars	-	01
Cabs	-	13
Jeeps	-	05
Motor bicycles	-	45
Three Wheelers	-	01

16. FINANCE UNIT

Total budgetary allocation for this year is 105.65 million and out of which 82.65 million under recurrent and 23 million under capital expenditure. Income forecast for this year was 12.15 million. Therefore the government grant was 83.27 million.

Preparing Institutional Budget cash flow and the final accounts are main functions of the Unit in addition to preparing monthly salaries and making routine payments.

17. ENGINEERING UNIT

Engineering Unit carried out maintenance work of buildings, electricity, vehicles, and machineries and attended to the following construction and rehabilitation works during the year 2004.

- Renovation of staff quarters BE/GR/IV/05 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/IV/10 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/IV/12 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/III/02 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/III/03 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/III/06 at Bandirippuwa Estate
- Repairs to the TTT'S Store Building at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/IV/04 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/IV/17 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/III/30 at Bandirippuwa Estate
- Modification to the Existing Copra Kiln
- Renovation of staff quarters BE/GR/II/01 at Bandirippuwa Estate
- Repairing of staff quarters BE/GR/II/04 at Bandirippuwa Estate
- Repairing of staff quarters BE/GR/II/05 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/I/23 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/IV/15 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/I/25 at Bandirippuwa Estate
- Renovation of staff quarters BE/GR/IV/16 at Bandirippuwa Estate
- Construction of Aluminium Partitions for the Establishment Unit

STAFF PUBLICATIONS/COMMUNICATIONS AT SCIENTIFIC MEETINGS

Thesis

Nainanayake, N P A D - Impact of drought on coconut (*Cocos nucifera* L.): screening the germplasm for photosynthetic tolerance in the field, Ph D thesis, University of Essex, UK.

JOURNAL PAPERS, PRESENTATIONS AT SEMINARS/WORKSHOPS AND SCIENTIFIC SESSIONS

Appuhamy, P A H N, 75 Years excellence in Coconut Research, Coconut Technology Update, Issue 1, April, 2004.

Appuhamy, P A H N, A new pest of Coconut – *Plesispa reichei*, Coconut Technology Update, Issue 2, August.2004.

Appuhamy, P A H N, CRIC 65 Hybrid for 2004, higher production, Coconut Technology Update, Issue No. 2, August 2004.

Appuhamy, P A H N, Experience in Technology Transfer activities of the Coconut Research. Proceedings of the International Conference of the Coconut Research Institute of Sri Lanka – part 02 The Coconut Research Institute of Sri Lanka, Lunuwila 61150, Sri Lanka – pp 285-295.

Bandaranayake, C K (2004). Genome mapping using Sri Lankan coconut germplasm: Current status and future. Proceedings of the International Conference of the Coconut Research Institute, Sri Lanka – Part II: (Eds: T.S.G. Peiris and C.S. Ranasinghe) : in press

Bandaranayake, C K (2004). Happy mapping as an alternative to overcome the problems in coconut genome mapping. *CORD* 20(2): 37-42

Bandaranayake, C K, Koumproglou, R, Wang, X Y, Wilkes, T and Kearsey, M J (2004). QTL analysis of morphological and developmental traits in the Ler x Cvi population of *Arabidopsis thaliana*. *Euphytica* 137(3): 361-371

Everard, J M D T (2004). From Ceylon Latin Square to Coconut Genome Framework – A relentless journey. Proceedings of the International Conference of the Coconut Research Institute, Sri Lanka – Part I (Eds: T.S.G. Peiris and C.S. Ranasinghe) : 1-10

Everard, J M D T, Jayathilaka, R and Bandaranayake, C K (2004). Sri Lankan Tall x San Ramon: The best received coconut cultivar in the country. Proceedings of the first symposium on plantation crop research: - current trends and future challenges (Eds: A.K.N. Soyza and M.T. Siyad Mohamed) ; 116-126

Everard, J M D T, Perera, L and Bandaranayake, C, participated in the awareness workshop on GMO/GMF and biosafety for scientists, Coconut Research Institute, Sri Lanka, 22 May 2004

Everard, J M D T and Perera, L, participated in the Workshop on capacity building in biosafety of genetically modified crops in Asia, Auditorium of the Plant Genetic Resources Centre, and Peradeniya, Sri Lanka from 31 May to 1 June 2004

Fonseka, H D N H, The Importance of Interactive Multimedia programmes (IMM) as an effective extension material in the coconut sector of Sri Lanka. Proceeding of the International Conference of the Coconut Research Institute of Sri Lanka – Part 2. The Coconut Research Institute of Sri Lanka, Lunuwila 61150, Sri Lanka pp.295-300.

Fernando, S C, Weerakoon, L K, Perera P I P, Banupriya H D D, Ambagala, E, Gamage, C K A, Santha, E S, Gunathilake, T R and Perera L (2004). " Genetic fidelity and *Ex vitro* performance of tissue cultured coconut plants). Proceedings of the International Conference of the Coconut Research Institute, Sri Lanka – Part II: (Eds: T.S.G. Peiris and C.S. Ranasinghe) : in press

Fernando, M T N (2004). Influence of socioeconomic and communicative factors on the adoption of coconut-based intercropping systems in Sri Lanka. In Proceedings of the First Symposium on Plantation Crop Research, 8-9 July 2004, BMICH, Colombo. (Eds: A. K. N. Zoysa and M. T. Z. Mohamed) 228-250 pp.

Fernando, M T N and Jayalath, K V N N (2004). Gap between retail and farm-gate price of coconut: Is it widening? Journal of the National Institute of Plantation Management, 20 **(1)**, 19-25 pp.

Fernando, M T N and Jayalath, K V N N (2004). Local market price movement of fresh coconuts. Journal of the National Institute of Plantation Management, 20 **(1)**, 26-34 pp.

Fernando, M T N, Jayalath, K V N N and Dissanayake, A M U (2004). Changes in land extent under coconuts within two decades 1982-2002: Evidence from fifteen districts in Sri Lanka, *Economic Review*, 30 **(5/8)**, 11-13 pp.

Fernando, S C, Ranasinghe, C S, Weerakoon, L K, Hirimburegama, K (2004). Biochemical studies of *Cocos nucifera* L. (coconut) embryogenesis. *Proc. Sri Lanka Assoc. Advmt. Sci.* 60, 38.

Gunathilaka, H A J, Mono-culture to crop diversification: sole prospect for sustainability of coconuts. Proceeding of the International Conference on Golden Jubilee Coconut Research Institute-Part I. 8-10 September 2004, Trans Asia Hotel, Colombo. (Eds: T. S. G. Peiris and C. S. Ranasinghe) 37-35 pp.

Herath, C, Jayawardhana, J K J P, and Appuhamy, P A H N, Asessment of knowledge level and factors affecting adoption of Red Weevil control measures of the small holding sector in the Kuliyapitiya Region, Proceedings of the International Conference of the Coconut Research Institute of Sri Lanka – part 2. The Coconut Research Institute, Lunuwila, Sri Lanka. pp. 346-353.

Jayawardhana, J K J P, Herath, C and Ranasinghe, C S, Assesment of Present situation and constraint of the coconut small holders in the Kuliyapitiya Region, Proceedings of the International conference of the Coconut Research Institute of Sri Lanka – part 2.

Madurapperuma, W S, Ranasinghe, C S, Mendis, H C, Premasiri, R D N, Saram, P S A De and Gunawardane, M (2004). Application methods of zinc and the effect of macro- and micro nutrient applications on the expression of Leaf Scorch Decline symptoms in coconut (*Cocos nucifera* L.). In: Abstracts of the International Conference of the Coconut Research Institute of Sri Lanka, Part II, 8-11 September, Colombo, 58.

Nainanayake, N P A D, Morrison, J I L M (2004) Screening of coconut germplasm for drought tolerance based on physiological traits, In: Abstracts of the International Conference of the Coconut Research Institute of Sri Lanka, Part II, 8-11 September, Colombo, 21.

Nanayakkara, K W, Fernando, M T N, Gunarathna, L H P and Jayalath, K V N N (2004). Determinates of exports demand of coir fibre and coir fibre products in Sri Lanka: Implications for exports promotion. Proceeding of the International Conference on Golden Jubilee Coconut Research Institute-Part II, 8-10 September 2004, Trans Asia Hotel, Colombo. (Eds: T. S. G. Peiris and C. S. Ranasinghe), 161-172 pp.

Peiris, T S G, Fernando, M T N and Samarajeewa, S R (2004). Factors influencing the use of coconut oil by the householders in Sri Lanka and the policy relevance to popularize the consumption of coconut oil. Int. J. of Coconut Research and Development, 20 **(2)** 12-20.

Perera, L, Fernando, W B S F, Herath, N, Fernando, A, Russell, J, Provan, J and Powell W (2004). "Use of microsatellite DNA markers for population analysis, variety identification and for hybridity testing of coconut in Sri Lanka. Proceedings of the International Conference of the Coconut Research Institute, Sri Lanka – Part II (Eds: T.S.G. Peiris and C.S. Ranasinghe) : In press

Perera, S A C N, Wilkes, T M, Kearssey, M J (2004). A Functional Genomic Approach for Fine Mapping of QTL. Annual Symposium of the Society of Developmental Biology and Genetics, 2004. 14 – 16 March, University of Warwick, UK

Perera L (2004). "Analysis of coconut populations by microsatellite markers" Proceedings of the International LINK2PALM2004 symposium on "Advances In biotechnology application to coconut and oil palm", Manila Pavilion hotel, Mania, Philippines, April 19-21

Perera, S A C N., Wilkes, T M., Kearssey, M J (2004). Mapping Quantitative Trait Loci Governing Flowering Time in Arabidopsis Using Stepped Aligned Recombinant Inbred Strains. 15th International Conference on Arabidopsis Research 11-14 July, 2004, Berlin, Germany.

Perera, L and Bandaranayake, C, participated in the national workshop on policy development in biotechnology and biosafety for Sri Lanka at the, Sri Lanka Foundation Institute, Colombo from 26 July 2004

Perera, L and Bandaranayke, C, participated in the International training workshop on risk assessment and management of genetically modified organisms and genetically modified foods. National Bio-safety Framework Project, Ministry of Environment and Natural Resources, Sri Lanka. Trans Asia Hotel, Colombo from 15-16 October 2004.

Perera, L, participated in the training seminar on knowledge management for innovation, organized by Institute of Chemistry, Ceylon. Trans Asia Hotel, Colombo on 20 October 2004.

Ranasinghe, C S (2004). Physiology of coconut as a rational basis for crop improvement: achievements and current developments in Sri Lanka. Proceedings of the International Conference of the Coconut Research Institute of Sri Lanka-Part I. (review papers and guest presentations), 168-189 (Eds: T S G Peiris and C S Ranasinghe). The Coconut Research Institute of Sri Lanka, Lunuwila 61150, Sri Lanka.

Ranasinghe, C S (2004). Assessment of the impact of climate change on the yield of coconut using a growth simulation model. Sri Lanka association of the Advancement of Science (SLAAS) Section B seminar, SLAAS, Colombo 07, 22 November.

Samarajeewa, A D, Senarathna, S H S and Perera, K C P (2004). Effects of Imperata cylindrical on yield of Coconut (*Cocos nucifera*) in law country Dry Zone of Sri Lanka. *COCOS*, Vol. **16** , 37-42 pp.

Samarajeewa, A D, Samarajeewa, S R, Gunathilake, K D P P and Ranathunga, Y M M K (2004). Income generation from alternative coconut-based high value product and their profitability in rural poor communities in Sri Lanka. Proceeding of the International Conference on Golden Jubilee Coconut Research Institute-Part-II, 8-10 September 2004, Trans Asia Hotel, Colombo. (Eds: T. S. G. Peiris and C. S. Ranasinghe) 204-216 pp.

Samarajeewa, A D and Gamage, D V de S (2004). Nutrient Budget for Coconut (*Cocos nucifera*) based Restricted Scavenging Poultry Production System. Proceeding of the International Conference on Golden Jubilee Coconut Research Institute-Part II, 8-10 September 2004, Trans Asia Hotel, Colombo. (Eds: T. S. G. Peiris and C. S. Ranasinghe) 152-160 pp.

Samarajeewa, S R and Fernando, M T N (2004). The structure and performance of the coconut marketing system in Sri Lanka. Council for Agricultural Research and Policy. Sri Lanka.

Samarajeewa, S R and Samarajeewa, A D (2004). Women's income generation from Coconut-based cottage activities and its contribution to their food security in two rural poor communities in Sri Lanka. Proceeding of the International Conference on Golden Jubilee Coconut Research Institute-Part II, 8-10 September 2004, Trans Asia Hotel, Colombo. (Eds) T. S. G. Peiris and C. S. Ranasinghe, 173-182 pp.

Senarathna, S H S (2004). Effects of different herbicide combination on weed control in coconut nurseries in the dry zone of Sri Lanka. Proceeding of the International Conference on Golden Jubilee Coconut Research Institute-Part II, 8-10 September 2004, Trans Asia Hotel, Colombo. (Eds: T. S. G. Peiris and C. S. Ranasinghe) 303-310 pp.

Senarathna, S H S Samarajeewa, A D and Perera, K C P (2004). Comparison of different weed management systems and their effects on yield of coconut plantations in Sri Lanka. Weed Biology and Management, Vol. 3, 158-162 pp.

Tennakoon, N A (2004). Fertilizer recommendation in Sri Lanka to increase coconut productivity. Paper presented at the International Conference of the 75th Anniversary of Coconut Research Institute held in Trans Asia Hotel, Colombo, Sri Lanka, 8-10 September, 2004.

Tennakoon, N A, Fernando, K S K S and Widanapathirana, S (2004). Organic manure towards improvement of microbiological status and soil environment of coconut lands in Sri Lanka. Paper presented at the International Conference of the 75th Anniversary of Coconut Research Institute held in Trans Asia Hotel, Colombo, Sri Lanka, 8-10 September, 2004.

Tennakoon, N A. Talks on the Use and importance of organic manure for coconut, b) Use of inorganic fertilizer for coconut and c) Water availability in Puttalam District were broadcast by the Sri Lanka Broadcasting Corporation under "Kapruka Pamula" Programme on 14th August, 30th October and 06th November, 2004 respectively.

Wijebandara, D M D I, Ranasinghe, C S (2004). Response of Rapid Decline affected coconut (*Cocos nucifera* L.) palms to micro nutrients and common salt. COCOS 16, 11-21.

Wijebandara, D M D I, Tennakoon, N A and Somasiri, L L W (2004). Evaluation of major nutrient availability of soils by green house study. Paper presented at the first symposium on Plantation Crop Research held in BMICH, Colombo, Sri Lanka 8-9 July, 2004.

Wijebandara, D M D I and Somasiri, L L W (2004). Micro-nutrient status of coconut growing soils in Sri Lanka after application of organic manure and NPK fertilizer. Paper presented at the International Conference of the 75th Anniversary of Coconut Research Institute held in Trans Asia Hotel, Colombo, Sri Lanka, 8-10 September, 2004.

Wijeratne, M A, Peiris, T S G, Aanadacumaraswamy, A, Ranasinghe,C S, Jayakody, A, Fernando, M T N, Ratnasiri, J (2004). Impact of climate change on coconut and tea industry in Sri Lanka, 2nd Asia and Pacific Regional workshop on assessment of climate change impacts, Manila, Philippine, 2-5 November.

Wijesekera, R S, Rajapakse, R A G R R, Tennakoon, N A and Somasiri, L L W (2004). Hydrological study on deep ground water aquifers in the coconut growing areas of Kurunegala District. Paper presented at the symposium on "The Water Professionals Day" held in Postgraduate Institute of Agriculture, Peradeniya, Sri Lanka, 01 October, 2004.

ACADEMIC AND PROFESSIONAL ACTIVITIES

Bandaranayake, C, served as a visiting lecturer in Plant Molecular Biology for the M.Sc. course in Applied Biotechnology at the PGIS, University of Peradeniya.

Bandaranayake, C, supervised the research project of Miss C Samarasekera an M.Sc. student offering the M.Sc. course in Applied Biotechnology at the PGIS, University of Peradeniya.

Everard, J M D T, served as a visiting lecturer in Plant Molecular Biology for the M.Sc. course in Applied Biotechnology at the PGIS, University of Peradeniya.

Everard, J M D T, supervised the research project of Mr. Tharaka Punchi Bandara an M.Sc. student offering the M.Sc. course in Applied Biotechnology at the PGIS, University of Peradeniya.

Everard, J M D T, supervises two Ph.D. research programmes, use of molecular markers in tea breeding and molecular diagnosis of sugar cane diseases at the Biochemistry Department, Faculty of Medicine, University of Colombo.

Everard J M D T, served in the organizing committee of the first symposium on Plantation Crop Research held at the BMICH from 8-9 July 2004.

Tennakoon, N A, supervised a NIPM Project of Mr. Lucian Silva.

REPORT OF THE ACCOUNT UNIT
FINANCIAL PERFORMANCE REPORT
Accountant - R M U Chandranath, BSc Mgt.

The Coconut Research Institute's prime income comes from Treasury funds and other incomes generated from four Genetic Resource Centres, five Research Centres, CESS grant and Donor Funded Project 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			
	2001	2002	2003	2004
Treasury Grant – Recurrent	63.50	57.00	52.77	60.27
Treasury Grant – Capital	12.70	7.25	27.50	22.26
Income Self-finance Units	41.95	35.18	46.98	55.00
CRI Own Income	2.40	3.43	5.75	4.98
CESS Grant	14.12	14.88	12.50	20.67
Donor Funded Projects	3.63	7.15	7.72	8.45
Total	138.30	124.89	153.22	171.63

As shown in Table 1, the consolidated funds have increased by 14% in the year 2004 compared to year 2003. The income generation of self-financing units had increased by 17% when compared to previous year.

Table 2 : *Financial progress of recurrent and capital expenditure*

Description	Rs. Million		(Decrease) %
	2003	2004	Increase
Personnel Emoluments	55.59	63.59	14.4%
Travelling Expenses	0.93	1.90	17%
Supplies and Requisites	6.32	6.06	(4%)
Maintenance Expenses	10.18	12.41	22%
Contractual Expenses	4.14	4.95	20%
Other Recurrent Expenses	0.92	1.84	100%
Total Recurrent Expenses	**78.08**	**90.75**	**16%**
Total Capital Expenses	**21.78**	**18.70**	

The staff position of the CRI was 635 employees during the year 2004. Out of them 318 were permanent employees, ten were on contract basis and 307 were daily paid workers. As indicated in Table 2, 70% of the total recurrent expenditure was on personnel emoluments and the next highest expenditure was on maintenance such as buildings, vehicles, electricity, infrastructure development etc. Fuel and lubricant were included under supply expenditure and telephone, Internet, insurance, security charges, legal fees etc. included under contractual services. Public Finance Circular No. 15/2003 was negatively influenced the recurrent budget.

Table 3: *Financial Progress of Self-financing Units*

Seed Gardens/ Research Centres	Year 2004		Surplus/ (Deficit)
	Income Rs. Million	Expenditure Rs. Million	
Ambekela Genetic Resources Centre	15.56	10.30	5.26
Pallama Genetic Resources Centre	6.73	5.58	1.15
Makandura Genetic Resources Centre	4.20	1.59	2.61
Maduruoya Genetic Resources Centre	4.08	3.51	0.57
Bandirippwa Research Staton	6.70	5.67	1.03
Rathmalagara Research Centre	8.13	7.58	0.55
Walpita Research Centre	1.68	1.47	0.21
Pottukulama Research Centre	7.34	4.79	2.55
Dunkannawa Research Centre	0.60	1.22	-0.62
Estates Management Division		1.11	-1.11
Total	**55.02**	**42.82**	**12.2**

Pallama Genetic Resource Centre and Dunkannawa Research Centre had been vested recently and therefore these two estates are in an improvement stage.

Estimated and achieved coconut production was 5,250,000 and 5,138,217 respectively.

Table 4: *Financial Progress of Cess Funded Projects*

Seed Gardens/ Research Centres	Year 2004		Balance From Allocation
	Allocation Rs. Million	Expenditure Rs. Million	
Application of Bio-Technology	2.80	0.73	2.08
Strengthening Analytical Facilities for DFR	1.16	0.60	0.57
Controlling Mite Damage	1.81	1.36	0.46
Red Weevil Pheromones	0.35	0.07	0.28
Development o Pallama Seed Garden	3.32	0.46	2.86
Development of Maduruoya Seed Garden	0.20	0.18	0.02
Coconut Germplasm exchange in Sri Lanka Ivory Coast	2.00	1.17	0.83
CRI 75 Years Anniversary Celebration	1.80	1.80	0.00
Technology Transfer Programme	7.00	2.13	4.87
Increasing to Production of CRI 65 Seed Nuts	3.87	0.68	3.18
Renovation of Official Quarters & Buildings	7.10	1.17	5.93
Est. of a Coconut Res. Station in Southern Province	5.00	0.06	4.94
Construction of Laboratory Building for Mite	5.00	0.10	4.90
Total	**41.40**	**10.51**	**30.90**

COCONUT RESEARCH INSTITUTE
ESTABLISED UNDER COCONUT DEVELOPMENT ACT NO. 46 OF 1971
BALANCE SHEET AS AT 31 st DECEMBER 2004

		YEAR 2004 Rs.	YEAR 2004 Rs.	YEAR 2003 Rs.
ASSETS				
Property,Plant & Equipment	NOTE-01	141,633,431.09		140,210,136.63
Research & Development	NOTE-1.1	9,784,804.59		6,253,336.23
			151,418,235.68	146,463,472.86
CURRENT ASSETS				
Stocks	NOTE-02	20,750,701.55		20,772,635.36
Debtors Less Provision	NOTE-03	1,309,483.56		1,893,122.33
Purchase Advances	NOTE-04	1,661,181.45		537,958.32
Loans And Advances To Employees	NOTE-05	16,547,303.13		16,660,502.63
Deposits Receivable		134,400.00		134,400.00
Saving Deposit	NOTE-06	1,006,000.00		119,844.11
Prepayments		75,607.23		892,890.95
I.A.E.A. Project		5,513.29		5,513.29
Cash -In -Transit		3,621,039.95		6,519,855.24
Cash & Cash Equivalants	NOTE-07	21,492,130.98		11,197,374.16
				58,734,096.39
Total Assests			**218,021,596.82**	**205,197,569.25**
LIABILITIES				
Current Liabilities				
Sundry Creditors	NOTE-08	207,118.66		237,063.60
Accrued Expenses		7,668,268.87		8,840,985.41
Expenses Creditors		2,273,746.51		1,124,613.20
Deposits Payble	NOTE-09	536,337.42		257,398.34
On Going Projects	NOTE-10	7,542,646.56		3,051,108.03
Working Capital			18,228,118.02	13,511,168.58
NON CURRENT LIABILITIES				
Provision For Gratuty			42,215,152.00	30,353,223.91
Total Net Assets			60,443,270.02	43,864,392.49
			157,578,326.80	**161,333,176.76**
NET ASSETS/EQUITY				
Authorised Capital			18,000,000.00	18,000,000.00
Contributed Capital	NOTE-11	272,241,959.10		249,981,959.10
Contributed Capital-Project		3,328,965.74		0.00
Foreign Aid		634,078.78		634,078.78
Local Aid		4,819,171.82		4,819,171.82
Capital Reserve		11,218,173.46		11,218,173.46
Revenue Reserve	NOTE-12	(134,664,022.10)		(105,320,206.40)
			157,578,326.80	161,333,176.76
			157,578,326.80	**161,333,176.76**

DEPUTY DIRECTOR (A & F)
COCONUT RESEARCH BOARD

MEMBER
COCONUT RESEARCH BOARD

CHAIRMAN
COCONUT RESEARCH BOARD

COCONUT RESEARCH INSTITUTE
STATEMENT OF FINANCIAL PERFORMANCE FOR THE YEAR
ENDED 31st DECEMBER 2004
ILLUSTRATION THE CLASSIFICATION OF EXPENSES BY NATURE

	YEAR 2004 Rs.	YEAR 2003 Rs.
OPERATING REVENUE		
Recurrent Grant	60,270,000.00	52,770,000.00
Estate Income	55,004,289.02	40,549,946.66
Interest On Loan & Investment	635,111.98	657,953.59
Income From Motor Vehicles	1,302,828.31	873,649.54
Sundry Income	2,837,798.21	3,837,287.56
Sales Of Pheromone	169,890.00	121,350.00
Sales Of Monocrotophose	34,920.00	260,720.00
Income Projects	5,118,708.28	0.00
	125,373,545.80	**99,070,907.35**
OPERATING EXPENSES		
Salaries Allowances & Over Time	38,778,505.86	43,846,798.46
Boards Contribution To ETF/EPF	5,754,100.33	6,517,765.96
Boards Contribution To Medical Aid	2,449,654.52	2,642,800.35
Coconut Allowances	245,281.61	303,996.48
Estate General Charges/Upkeep/Cultivation & Harvesting	46,724,295.08	17,708,382.71
Travelling	1,089,754.49	932,325.24
Suppliers & Consumable	6,055,065.44	6,321,110.98
Maintenance	12,409,163.82	10,150,298.40
Contractual Services	4,952,844.21	4,136,872.22
Depreciation & Amortisation Expenses	12,745,541.29	11,029,654.00
Expenses - Projects	5,118,708.28	0.00
Board Members Fees	47,950.00	87,275.75
Gratuity	15,630,620.61	2,186,479.50
Other Operating Expenses	2,791,059.21	916,953.48
Total Operating Expenses	**154,792,544.75**	**106,780,713.53**
Surplus/(Deficit) From Operating Activities	**(29,418,998.95)**	**(7,709,806.18)**
Finance Cost	-	-
Gain On Sales Of Property Plant & Equipments	-	2,036,057.00
Total Non Operating Revenue (Expenses)	**(29,418,998.95)**	**(5,673,749.18)**
Net Surplus / (Deficit) Before Extra Ordinary Items	-	-
Extra Ordinary Items	-	-
Net Surplus / (Deficit) For The Period	**(29,418,998.95)**	**(5,673,749.18)**

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