COCONUT RESEARCH BOARD

COCONUT RESEARCH INSTITUTE OF SRI LANKA

REPORT FOR 2003

COCONUT RESEARCH INSTITUTE - REPORT FOR 2003

COCONUT RESEARCH BOARD

REPORT OF THE
COCONUT RESEARCH INSTITUTE
FOR 2003

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S Alahakoon

Senior Supervisor

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A G B G Silva

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Senior Supervisor

T M Keerthiratne

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Officer-in-charge

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Pottukulama Research Station

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Superintendent	*Senior Clerk/Typist*
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**** **Sabbatical Leave**

THE COCONUT RESEARCH INSTITUTE
LUNUWILA

The Board and Institute

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

Mission of the CRI:

Our Mission is through Innovative Research and Development:

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

by employing a qualified and dedicated team of Scientists.

Functions of the Institute

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

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

The Coconut Research Board

The governing body of the Institute is the Coconut Research Board. In terms of the Coconut Development Act, the Board shall consist of 7 members, appointed by the Minister in-Charge. One member is appointed as the Chairman of the Board. The members hold office for 3 years and are eligible for reappointment.

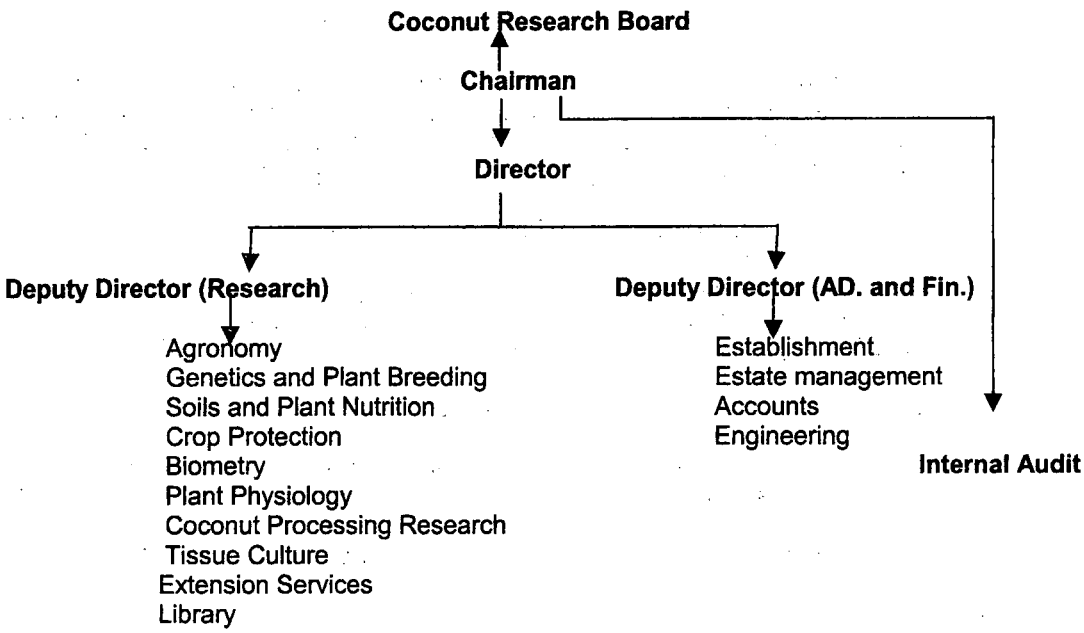
The members of the Board as at 31 December 2003 were:

Dr U P de S Waidyanatha	-	Chairman (up to September 2003)
Dr S S B D G Jayawardane	-	Chairman (w.e.f October 2003)
Dr D Kirtisinghe	-	Member
Mr F Richie Fernandopulle	-	Member
Mr C D V Aponso	-	Member
Mr A Hettiarachchy	-	Member
Mrs Indrani Sugathadasa	-	Member/ Representative of the Ministry
Dr R H S Samaratunga	-	Member/ Representative of the Treasury
Mr H A Tillekeratne	-	Observer member /Chairman CDA
Mr Lincoln Fernando	-	Observer member /Chairman CCB

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 laid down by the Board.

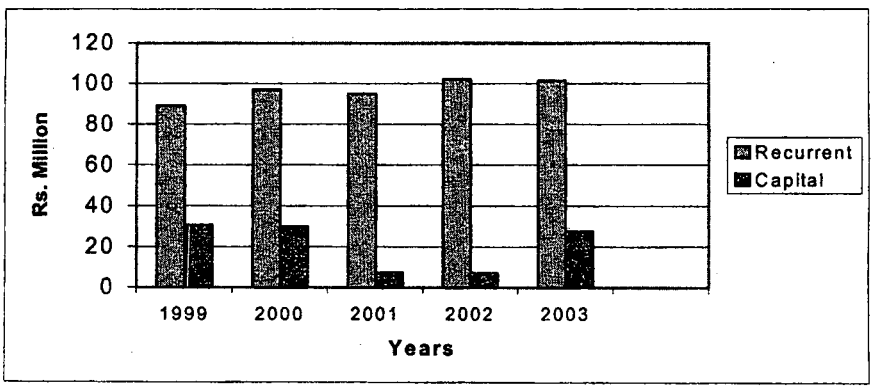
Deputy Director (Research) and Deputy Director (Administration and Finance) directly supervise the Research and Service Divisions of the Institute respectively as given below:



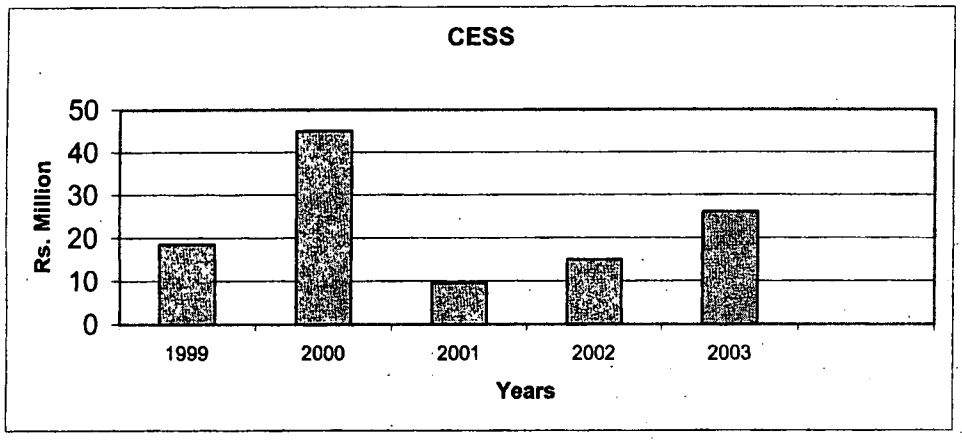
The Internal Auditor is directly responsible to the Chairman

Funding

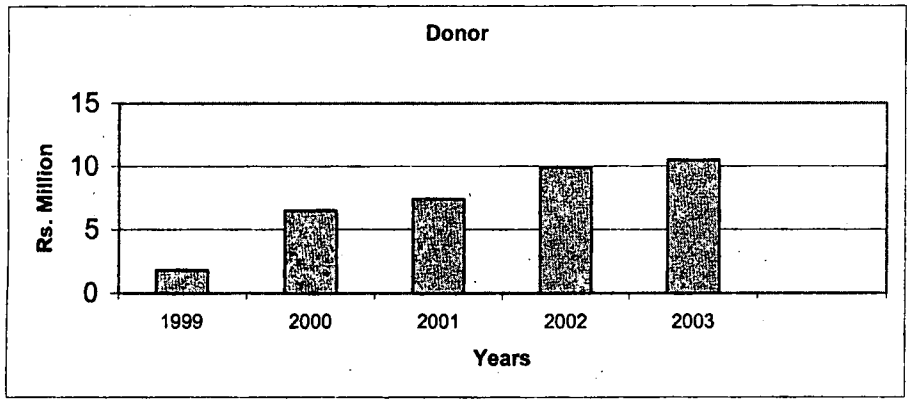
As a public sector organization, CRI is primarily dependent on government funding (Consolidated Fund). Limited amount of research funding is received from outside funding sources and competitive research grants from Council for Agriculture Research Policy. However, reduced spending for research and extension due to severe budget cuts severely constrain research and maintenance activities of the Institute. Government funding as capital and recurrent expenditure for the last four years is given below:



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



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



Review of Coconut Research Institute Performance During 2003

Dr S S B D G Jayawardane, M Sc, Ph D (Kyoto)
Chairman/CRB

The Coconut Research Institute founded in 1929 completes 75 years of its existence and services to the coconut industry is preparing to celebrate 75 years anniversary in 2004. Year 2003 under review was a critical year to the CRB as CRI had to face the challenges of accepting reforms and organizational re-structuring proposed by the Government's program on Regaining Sri Lanka.

While continuing the research activities undertaken according to the corporate plan of the Institute, special efforts were made during 2003 to consolidate research and development activities in managing the coconut mite pest outbreak. During the year 2003, mite infestation spread to many other Dry Zone and Intermediate Zone districts demanding intensified research both in laboratory and field. Therefore, during this year coconut mite research programme received the highest priority and many successful programs have been initiated as practical and economic measures to bring the pest under control.

Although, very encouraging results have been reported about mite control by predator mite, inability to apply this technology in the field was not appreciated by the growers whose fields have been seriously infested. Institute efforts to work with other experienced Scientists in Universities and Dept. of Agriculture in sharing their experiences and advice has brought about speedy progress to the on-going research on mite.

It is encouraging to note the ever increasing demand for the CRISL 98 (Tall x San Ramon). However, the Institute's inability to supply adequate seedlings to meet the demand due to limited availability is disappointing the coconut growers. Therefore, efforts are being made to increase the capacity to produce more seed nuts of the new cultivars produced by the institute. Narrow genetic diversity available to the plant breeders was a serious limitation to develop new cultivars of wide genetic base suitable for cultivation under different growing environments and to meet the other industrial needs. Introduction of new germplasm from Papua New Guinea during 2003 was a remarkable achievement to enhance the genetic diversity available to the plant breeding programs. Identification of a rich bio-diversity hot spot around Unawatuna village is a significant breakthrough in Institute efforts to expand *in situ* conservation and diversity assessment.

Technologies generated by the processing and product development research programme has not been readily taken up by the industry and other private sector investors mainly due to lack of incentives to start new industries in the coconut product development sector. Institute has initiated programs to assist the industry stakeholders by identifying their industrial needs and working in partnership in research and development activities.

Research information on intercropping experiments and efforts to transfer this technology through demonstrations, adaptive research and field days have helped many growers to enhance their income while sustaining high adoption rate of institute recommendations by large number of coconut growers. Consequent to the government efforts to promote the establishment of mechanized irrigation systems through loan schemes, demand for research information and institute's work with the Water Resource Board in identifying the availability of ground water resources in few Districts has been very useful and this knowledge was effectively communicated through seminars and field days which were highly valued and appreciated by growers.

Research Committees have been strengthened by bringing about more stakeholder participation to ensure need base research to meet the demands of the stakeholders and to bring about partnership in research and development.

Decision to restructure the institute's research and development from a disciplinary oriented approach to a program based approach will be in operation from year 2004. This change is expected to bring about high degree of integration among all disciplines making research outputs more relevant to stakeholder needs and at the same time this shift in approach will reduce the time taken to technology development and its transfer by bringing in farming system approach and assessment of economic feasibility of technology during its adoption by the growers.

In response to a demand for more effective and vibrant extension program on coconut cultivation by the Coconut Cultivation Board, CRI re-examined its technology development and its transfer procedures and mechanisms. Absence of a strong formal linkages and effective mechanisms to transfer the technology developed, to the growers through the responsible extension agency, that is the CCB was a serious draw back in the smooth flow of information. This situation has been rectified by formalizing regular meetings and linkage mechanisms with officials of CCB and CDA while enhancing CCB and CDA staff participation in CRI Research Committees etc.

Short supply of high quality seedlings of recommended superior cultivars to meet the replanting targets was a serious issue in achieving the national targets to maintain three billion annual nut production and to reach four billion level targets in 2010. In order to overcome this situation, CRI took leadership in inviting private sector participation in the production of seedlings. Response of the private sector and growers was very encouraging and Institute efforts and willingness to work with the private sector in these tasks could be viewed as a shift in attitude. Institute readiness to react to the timely needs and be more effective in delivering research goals is well reflected in its decision to assist in developing the capacity and capability of Mahaweli Plantations in establishing its Parasite Breeding Laboratory to meet their own demand of predators and also to supply others need in managing the coconut caterpillar pest.

THE COCONUT RESEARCH INSTITUTE
REPORT OF THE DIRECTOR
C JAYASEKARA, PH D (QLD)

1. GENERAL

The predicted national coconut production by the Institute was 2785 ± 5 million nuts for 2003 and approximate national coconut production estimated at 2605 million nuts was 9 percent increase in production compared to the previous year. A severe drought that prevailed in the latter part of year 2000 and early part of 2001 in the coconut triangle and in the Southern province contributed to this drop in production. However, this situation gradually improved with good rainfall experienced in the latter part of 2001 and in 2002 with good distribution throughout the year. Government assisted coconut fertilizer promotion programme also positively affected on gradual improvement of coconut production.

The average fresh nut prices in urban areas and in the Southern province increased sharply owing to the short supply of nuts in the first two quarters. The recorded average fresh nut prices during that period varied from Rs.15.00 to Rs.20.00. The State sector organizations maintaining coconut estates mainly Coconut Cultivation Board (CCB) and Coconut Research Institute (CRI) and "Sathosa" acted immediately to ease the short supply of nuts to the consumer by providing their estate crop to "Sathosa" outlets and in open markets at a lower price. The performance of kernel and other coconut processing sectors improved gradually with improved supply of nuts to the processing sector during the latter part of the year. The export earnings from kernel products during the year was Rs. 6672.94M. Total nut consumption during the year was estimated to be 1834M nuts. Recorded export earnings from non-kernel based coconut products was Rs. 9990.14M. Moreover, local uses of coconut as a source of fat, protein, sugar, fuel, alcohol, construction material, and timber are taken into account, contribution of the crop to the national economy was approximately Rs. 27 billion and its contribution to the food and food security of the nations is also worth mentioning.

The allocation for the Coconut Research Institute from the Consolidated fund and the coconut CESS, was Rs 91.312 million and Rs12.5 million respectively for research and maintenance. This amount was ~ 0.33% of the total contribution of this industry to the national economy.

The five-year research programme implemented in the year 2001 was prioritized by inviting stakeholders of the industry in the latter part of the year 2002. Research funding in the year 2003 was based on priority research programmes and industry needs due to limitation of funds. The Research Committee comprehensively reviewed the research programme in the third quarter of 2003. Experiments that provided adequate data were terminated. Several new recommendations arising out of these experiments were made available to the growers. Other long-term experiments will be continued for few more years. Several new research areas were identified and new research proposals were formulated after discussing them with the Research Committee and the research staff. The progress of the research programme was satisfactory. Most of the field experiments were conducted in substations of the Institute, estates belonging to Plantation Companies, National livestock Board, Coconut Cultivation Board, and private estates. Hundred and twelve coconut-based crop models in coconut small holdings in all coconut growing districts, excluding North and East established under the financial assistance of the second phase of the Perennial Crop Development Project, continued with satisfactory progress. These field sites were used regularly for field days and other technology transfer activities.

During the year institute paid much attention on the development of Integrated Pest Management (IPM) strategies for coconut mite (*Aceria guerreronis).* A feeding source for high fecundity of predator mite *Neosilus paspalivorous* was identified and a technique was successfully developed for mass breeding of the predator mite in the laboratory. Very encouraging results were obtained with studies conducted to determine the possible use of entomopathogenic fungus *Hirsutella thomsonii* for the control of coconut mite.

Mite infestation was reported in new areas like Hambanthota and Tissamaharama. On set of dry weather due to the failure of north - east monsoon aggravated the mite infestation in dry areas of the country.

The multidisciplinary research project on 'Rapid Decline Syndrome' (RDS) of coconut palms with technical assistance of the Food and Agriculture Organization (FAO) of the United Nations was continued successfully until October 2003. Molecular marker studies revealed that phytoplasma like organisms are not the causative agents for this syndrome. However, these studies were further continued to reconfirm the results. In December 2003 CRI has to abandon these experiments due to taking over of the Makandura Seed Garden by the Board of Investment, Kurunegala.

Another noteworthy achievement was the successful culturing of more than 50% of the coconut embryos of four cultivars brought from India. During the year another 10 exotic coconut germplasm were brought to the country from Papua New Guinea as 2000 embryos. Some of the embryo cultured coconut plants from India will be field planted in 2004.

The two Seed Gardens maintained by the Institute recorded a total production of 944761 seed nuts during the year, representing a 31 % increase, compared to the previous year. CRI supplied 1.139 million seed nuts from Ambakelle, Maduru Oya, and Pallama Seed Gardens to the CCB to raise seedlings for the National Replanting Programme. Planting of the Pallama Seed Garden with Ambakelle Tall and hand pollinated San Ramon seedlings was continued. More than hundred seedlings of San Ramon and Tall seedlings came into flower during the year. The total extent planted under the seed garden development programme stands at 4.5 hectares. In keeping with the government policy on privatization of seed material production a seminar was held at Hector Kobbakaduwa Agrarian Research Institute to explain the proposed seedling production programme. A programme was developed with the Seeds and Plant Quarantine Unit of the Department of Agriculture to allow private sector to raise coconut seedlings.

Exchange of coconut germplasm with Papua New Guinea was successfully completed by bringing 2000 embryos of 10 pacific varieties of coconut. Under the germplasm exchange programme with Papua New Guinea four Sri Lankan cultivars of coconut were given to them.

The Council for Agricultural Research Policy (CARP) continued to provide assistance to the Institute by funding for contract research projects and providing postgraduate training facilities to research staff through the MOA between ICAR and CARP. During the year CRI scientists secured 3 contract research grants worth approximately 5 million rupees to strengthen the research programmes on developing IPM strategies for coconut mite, Rapid decline syndrome of coconut, and to study coconut marketing systems.

The Coconut CESS fund pledged assistance for strengthening of infra structural facilities of the Research Centres and Seed Gardens, biotechnology research programme, and for the funding of special research projects to meet current needs of the industry.

Development of a performance based management system for the CRI with the assistance of Asian Development Bank (ADB) and International Service for National Agriculture Research (ISNAR) was completed. Corporate plan of the institute was prepared based on

the strategies identified for the future development of the institute. A restructuring plan of the Institute was proposed to the Coconut Task Force, with a view to reposition the CRI to meet new challenges of the coconut industry and to face the external pressures.

Research projects funded by foreign agencies such as Coconut Genetic Resource Net Work (COGENT) and International Fund for Agricultural Research and Development (IFAD) continued with satisfactory progress.

The Institute continued to provide technology transfer activities by conducting seminars and field days to the growers on selected topics. This gave an opportunity for the research scientists to establish a closer interaction with the planting community and get feedback to improve research programmes. A series of one-day training programmes were also offered to estate owners, superintendents, and other estate staff to educate and improve the adoption of technologies developed by the CRI to enhance the coconut production and productivity of coconut lands with increased income and profit. In order to strengthen technology transfer activities and to avoid duplication of activities with CCB the extension division was reorganized to involve only on technology transfer in collaboration with the Coconut Cultivation Board.

The budget restrictions imposed by the government, affected the effective implementation of the action plan of the Institute and had to curtail some facilities provided to the staff.

In keeping with the government policy on restructuring of Institutes under the Regaining Sri Lanka, a proposal was submitted to the Coconut Task Force for its consideration.

2. ACHIEVEMENTS AND HIGHLIGHTS OF RESEARCH DIVISIONS

2.1 Agronomy

Research programme on development of improved agronomic practices for increasing coconut production, increase productivity by intercropping, animal husbandry, fuel wood farming and studies on economic policy related issues were continued. During the year 23 field experiments and three socio economic studies were conducted under 10 major research projects. The total allocation of consolidated funds in terms of capital and recurrent budget for the above studies was Rs. 2.7 million.

Two major outside funded projects handled by the Division were the ADB funded; Coconut-based Adaptive Research Project (Rs. 2.0 million) and COGENT funded Poverty Reduction in Coconut Growing Communities (Rs. 2.8 million). Research project on soil moisture conservation in coconut lands revealed that mulching with coconut husks around the coconut palm proved to be beneficial by positively contributing on coconut yield over husk burial as a short-term measure to overcome drought effect. Economic analysis showed that husk burial is economically viable when husk price is lower than Rs. 550/- per 1000 husks. Planting coconut in large size holes (1.3 m x 1.3 m x 1.3 m pits) facilitated early flowering of coconut (56%) compared to the seedlings planted in standard pits of 1.0 m x 1.0 m x1.0 m (16%).

Application of glyphosate at the rate of 3.0 l per hectare was effective for control weeds in coconut nurseries and this practice saved Rs. 1480/- for 1000 coconut seedlings compared to manual weeding. More over Glyphosate 4.0 l per hectare was economically effective on control of weeds in mature coconut plantations compared to slashing and cover cropping.

Bud-grafted cashew performed better than cashew plants raised from seeds and air layered cashew seedlings. Although grafted cashew did not show negative effect on coconut yield,

air layered cashew reduced coconut yield by 12% over the control with no cashew plants indicating that competition of coconut/cashew root system. Adaptive Research Program revealed that intercropping pineapple and cinnamon was the most economical as a mid and long term intercrops in coconut lands. Program on fuel wood farming received high priority during the year considering the high demand from the growers and the industry. Feasibility of Gliricidia for gassifire technology to generate electricity was proven and it was revealed that 3.5 kg of gliricidia (at 20% moisture) is equivalent to 1.0 l of furnace oil. Each gliricidia tree yielded 5.8 kg of wood per annum and estimated yield per hectare was 15.0 mt/ha. This yield gained net profit of Rs. 15,000 per ha at Pallama Seed Garden. CRI was able to sell gliricidia to the Haycarb to generate electricity.

Coconut-based Adaptive Research Project conducted in 15 administrative districts (125 sites) revealed that application of organic fertilizers such as poultry manure was beneficial to increase coconut yield over chemical fertilizer at on-farm level. Degraded soils of farmer's fields could be rehabilitated with perennial crops such as cocoa, pepper, cashew and cinnamon. However, return to investment was highest (1:3.5) in coconut and pineapple system.

The project on assessment of the profitability and sustainability of semi-intensive poultry systems under coconut revealed that raising 75 birds (Breed:CPRS) in coconut smallholdings at 1/4 ac of coconut generate a net income of Rs. 2000/- per month. This production system with 75 birds is ideal for household women and it needs 2 hours of labour per day. The study also showed that the coconut lands with poultry, yielding 60 nuts per palm per year, supplementation of 500 g of MOP is sufficient to meet the palm nutrient requirements saving the cost of inorganic fertilizer by 80%. In pasture evaluation trials, B. ruzziensis is recommended for the smallholder dairy farmers in Low Country Intermediate Zone to be grown under coconut.

Under the project on "Development of sustainable Coconut-based Income Generating Technologies in poor rural communities", three community organizations have been successfully engaged in production of high value coconut products such as coconut shell handicrafts, coconut bracts handicrafts, virgin coconut oil, door mats, coir brushes, brooms and ekel brooms.

A survey of 70 households in Chilaw urban area to evaluate the market potential for virgin coconut oil, coconut jam, and bottled candied coconuts revealed that these households are prepared to buy these novel products, even by paying a premium price for virgin coconut oil. This implies that the rural communities could initiate the manufacture of these products, using the opportunities created for income generating activities through this project.

The study to evaluate the export potential of DC from Sri Lanka to Pakistan under FTA revealed that the consumer demand for DC in Pakistan is price responsive and is significantly and negatively influenced by consumers' income, implying that the proposed FTA would not likely to expand the DC trade significantly between the two countries.

The pay-back period of the drip irrigated coconut plantation of Mahaweli Coconut Plantation Ltd (MCPL) calculated using actual and budgeted data reveals that the plantation will take 11 years to generate a positive net return and 16 years to pay-back the accumulated costs, if the plantation will be continued as a coconut monocrop. The study also revealed that the above two time durations could be shorten to 6 and 9 years respectively, if monoculture coconut model is converted into a more intensive coconut-based intercropping model, implying the necessity of intercropping to make the pay-back period of monoculture coconut.

2.2 Genetics and Plant Breeding

The highlight of the year, 2003 was the liberalization of coconut seed and seedling production policy to obtain private sector participation in implementation of the national coconut-replanting program (NRP). Enrichment of the coconut germplasm by addition of ten exotic coconut varieties from the pacific (Papua New Guinea), discovery of seven new varieties of coconut from the Galle district, acquiring a 35-acre block from the Middeniya Farm of the Department of Agriculture (DOA) for establishing a gene bank in the southern province, securing CESS funds for expanding the CRIC65 production capacity at the Isolated Seed Garden, Ambakelle, commencing work towards constructing a segregating population for mapping of the coconut genome and completing the preliminary work towards establishing a multi-locational trial to test the combining ability of dwarf brown with tall coconuts are the other noteworthy accomplishments during the year. The on going long term experiments on genetic evaluation of existing cultivars and germplasm crosses and maintenance of the gene banks were continued successfully during the same period.

Coconut Research Institute (CRI) and Coconut Cultivation Board (CCB) responded positively to the request of the Ministry of Plantation Industries to seek active participation of the private sector in coconut seed and seedling production for the NRP. A proposal was put forward at a national forum organized by the Ministry of Plantation Industries in Colombo on 10th November 2003 for exploring possibilities for private sector participation in seed and seedling production in the three main plantation crops, coconut, tea and rubber. CRI in addition to already existing privately owned plus palm estates, invited private sector to establish seed gardens and nurseries for seedling production with the involvement of CRI. Assistance of Department of Agriculture (DOA) was solicited for providing certification for seedlings. Seedling distribution was another potential area identified for private sector participation.

Enrichment of the coconut germplasm was accomplished by collecting 200-300 embryos of ten coconut germplasm accessions from Papua New Guinea. The accessions namely, Kar Kar Tall, Markem Valley Tall, Rennell Island Tall, Gezelle Peninsuala Tall, Thalasia Tall, PNG Yellow Dwarf, Nias Yellow Dwarf, Malayan Red Dwarf, Malayan Yellow Dwarf and PNG Brown Dwarf are now being raised in Tissue Culture Laboratory of the CRI. Kar Kar Tall and Markem Valley Tall were collected from Kar Kar Island while the rest were collected from the Coconut Research Institute in Madang.

Unawatuna village was identified as a coconut bio-diversity hot spot in the country. Seven new coconut varieties were discovered from home gardens in an around Unawatuna village of the Galle district. These were clear phenotypic variants. In addition a wide variation in the normal tall coconut population was also observed. The local names of these varieties are ran pol, juwan pol, dothalu pol, thatin pol, bothal thambili, and murusi pol and naw pol.

CRI reactivated negotiations with the Ministry of Agriculture to acquire a portion of the Middeniya Farm for establishing a gene bank in the southern province. The main purpose of obtaining this land is to duplicate the exotic germplasm accessions collected from India and PNG. This program will be financially assisted by CESS.

The potential of CRIC65 for high input coconut farming and for home gardens was well recognized and a program was proposed to increase the production of CRIC65 at Ambakelle seed garden. Establishment of a drip irrigation system for mother (dwarf) palms and converting another tall field into a mixed field with dwarf are the main strategies identified and accepted for financial assistance from the coconut CESS fund for immediate implementation.

The novel approach, genome mapping for crop improvement was one of the newest projects identified by CRI for coconut improvement by marker assisted selection after establishing the Molecular Biology Laboratory in 2002. Establishing a segregating population of coconut as a prerequisite for mapping was commenced with initiation of a pollination programme comprising 23 dwarf red coconut palms and a single tall palm to establish an F_1 mapping population of 200-300 individuals. Initially a framework map will be constructed and subsequently mapping of QTLs will commence after establishing a progeny evaluation trial for scoring economic traits.

The on going long term experiments on genetic evaluation of existing cultivars and their crosses and maintenance of the gene banks continued successfully in all CRI and CCB estates and in private estates despite poor cooperation from some land owners. Data collection of the experiment on evaluation of cultivars was limited to two locations, Bandirippuwa and Suriyapura. Data collection in evaluation of progenies was also limited to three locations, Bandirippuwa, Rathmalagara and Daisy Valley estate (Mawathagama).

The performance of palms established in all the experiments have shown a recovery compared to the previous year where the yields were extremely poor due to drought prevailed in 2001. In the cultivar evaluation trial, inter-varietal hybrids continued to outperform pure tall cultivars in sites, at Bandirippuwa and Suriyapura where the experiment was continued with standard management practices. Both hybrids, *dwarf green x tall* and *dwarf yellow x tall* (CRIC65) recorded 14,400 nuts/ha/year against tall cultivars, *tall x tall* (CRIC60), *Moorock tall* and *plus palm tall*, which recorded 8800, 8000 and 8400 nuts/ha/year respectively at Bandirippuwa. *Dwarf green x tall* again recorded the highest yield of 12,800 nuts/ha/year at Suriyapura. *Dwarf yellow x tall, tall x tall* (CRIC60), *Moorock tall* and *plus palm tall*, recorded 12,800, 11,800, 7,800 and 10,200 nuts/ha/year respectively.

The evaluation of progenies arising from *tall x tall, tall x dwarf green* and *tall x San Ramon* at Bandirippuwa and Ratmalagara sites were also continued under standard management conditions. The performance of all three progenies was disappointing at the Bandirippuwa site. Yet the performance of *tall x dwarf green* was the best with an annual yield of 12,800 nuts/ha in comparison to yield recorded by *tall x tall* (7,800 nuts/ha) and *tall x San Ramon* (7400). Performance of all the three progenies at the Ratmalagara site showed a much better recovery with *tall x dwarf green* recorded as much as 20,400 nuts/ha/year. The corresponding yields of and *tall x San Ramon* and *tall x tall* were 10,600 and 13,200 nuts/ha respectively.

The highlight of experiment at the Daisy Valley Estate, Mawathagama was the performance of *dwarf green x San Ramon* in terms of copra productivity. *Dwarf x tall* or *tall x dwarf hybrids* continued to perform better than tall cultivars at the Daisy Valley (Mawathagama) Estate. *Dwarf green x tall* was the best with 10,000 nuts/ha and *tall x dwarf green* and *dwarf green x San Ramon* followed with annual yields, 9,400 and 9,200 respectively. The two tall cultivars, *tall x San Ramon* and *tall x tall* recorded only 6,800 and 6,600 nuts/ha during the year. Individual nut weights were significantly higher in progenies arising from San Ramon and copra/nut corresponding to five progenies, *tall x San Ramon, dwarf green x San Ramon, tall x tall, tall x dwarf green* and *dwarf green x tall* were 304, 275, 254, 229 and 216 g respectively. The copra productivity of the five progenies, *dwarf green x San Ramon, dwarf green x tall, tall x dwarf green, tall x San Ramon* and *tall x tall* were 2.53, 2.16, 2.15, 2.06 and 1.66 MT/year respectively.

The demand from the growers to establish CRISL98 (*tall x San Ramon*) was ever increasing despite the limited production. Still CRISL98 has to be produced by hand pollination. During the year 4,272 seedlings have been issued for over 30 growers in five districts, Puttalam (2,617), Kurunegala (1,170), Gamapaha (350), Colombo (60) and Vavuniya (75). Establishment of Pallama Seed Garden (PSG) for mass production of CRISL98 was

continued satisfactorily during the year. The total number of seedlings established to date were 9,555. In order to widen the parent palm population to increase the production of San Ramon seedlings to accelerate the establishment of seed garden more palms were identified for self-pollination from a mixed block at PRS. This identification became possible because of the recent DNA assay criterion developed by the CRI.

Conservation of coconut germplasm was continued satisfactorily at all the field gene banks. The performance of germplasm accessions at Raddegoda Estate was remarkably good due to excellent cooperation from the estate officials. The seven new varieties identified from the Unawatuna village was now undergoing selfing for obtaining pure seeds for conservation.

2.3 Soils and Plant Nutrition

Soils and Plant Nutrition Division, maintained fourteen on going field experiments and two new field experiments. The deep ground water survey, in the Kurunegala District carried out under CESS Fund was also continued during the year. The total research expenditure of the Division was Rs. 2,008,000/- while the maintenance cost was Rs.250,000/-

The experiment established to study site specific fertilizer recommendation at Mangala Eliya (S_2, DL_3) gave 30% yield increase of the palms receiving recommended APM over control (no fertilizer) palms. The difference was statistically significant. However, there was no further increase in yield due to application of fertilizer doses that were higher than the recommended dose. The results showed that the yield increase cannot be expected by applying more than the recommended fertilizer rates particularly in Borupana series of soil in the Dry zone where the site is located.

The experiment on fertilizer for king coconut palms at Walpita site, showed that the nut yield of the palms receiving APM was 56% higher than the control while that of palms receiving fertilizer equal to half of the quantity of nutrient removal was 42% higher than the control (no fertilizer). This result was obtained six years after the experiment. According to the results, it can be concluded that the best recommendation for king coconut is urea (N) 800 g, IRP (P) 600 g, MOP 1600 g and dolomite 1000 g per palm which is the same as APM for annual application.

By comparison of efficiency of 3 organic manures and a green manure with the recommended inorganic fertilizer (APM), it was found that the yield of the palms receiving poultry manure increased by 36% compared to the control (no fertilizer). With cow dung, goat dung and gliricidia, the yield increase was 31%, 33% and 15% over the control respectively while the yield increase due to inorganic fertilizer (APM) was 28%. The results of this experiment indicated that application of organic manures such as poultry manure, goat dung and cow dung is more beneficial than that of inorganic fertilizers.

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 sodium chloride, the difference was not statistically significant. The yield difference between the above two treatments were 23 nuts/palm/year, while it was 11 nuts/palm/year between sodium chloride and control (no fertilizer) treatments.

Drip irrigation experiment conducted at Ratmalagara Estate showed 71% yield increase compared to control (no irrigation) when irrigated at the rate of 40 l/day/palm at 6 days intervals with 250 g of APM plus 83 g of dolomite at monthly intervals. The yield of this treatment was 28% higher than application of 40 l/day/palm at the same interval but with application of 3 kg of APM and 1 kg of dolomite annually. This result shows that 12 split

applications of APM and dolomite with irrigation is more beneficial than irrigation alone. The latter treatment showed a 33% yield increase over the control.

2.4 Crop Protection

The Crop Protection Division continued 18 laboratory and field experiments during the year.

The research on coconut mite continued to receive the highest priority of the Division with the objective of developing an integrated pest management programme. The research was mainly focused on biological and chemical control methods. With the view of mass releasing laboratory–bred predatory mite *Neoseiulus* aff. *paspalivorus* in to the infested fields studies on rearing technology was successfully developed. A preliminary study to determine the effect of releasing predatory mites on to bagged infested bunches showed that about 70% reduction in coconut mite density could be obtained by using predatory mites. 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 the emphasis on the use of entomopathogenic fungus *Hirsutella thompsonii* was continued. A survey conducted in Puttalum, Anuradhapura, Kurunegala and Gampaha Districts indicated that *H. thompsonii* was present in all the areas, but the incidence of occurrence on nuts was less than 10%. Pathogenecity of the local strain of the fungus was proved. Preliminary field studies conducted to investigate the effectiveness of the laboratory-cultured fungus indicated over 80% mortality of coconut mites in 1-2 months after spraying the fungus twice at a 2-week intervals. Studies are in progress.

Preliminary field-testing of carbosulfan 20% (Marshal SC 20) indicated that repeated application of the chemical at monthly intervals by spraying and root feeding caused up to 80% mortality of mites and reduced the population by 76% while reducing the percentage infestation in the new bunches by 70%. Other tested chemicals did not give satisfactory control of the pest. Crown spraying of Neemarin gave only 30% mortality while chlorpyrifos and carbosulfan (Marshal 20 EC) gave 40% and 20% reduction in pest density respectively and did not reduce the damage on nuts. Preliminary testing of Admire SL 200 (imidacloprid 20%) by root feeding and spraying showed mortality up to 55% and 53% respectively. Econeem Plus (Azadirachtin 1%) did not show any efficacy on coconut mite by any application method. Studies indicated that application of 30% used engine oil mixed with water and surfactant on to the perianth of nuts gives nearly 100% mortality of coconut mites. After the treatment the damage on affected nuts discontinued while fresh damage was found on less than 2% of nuts. Unaffected nuts were free from damage throughout their development. Pilot trials are continuing to determine the frequency of application on newly developing nuts.

Studies on the diurnal pattern of migration of coconut mite showed that the number of mites leaving the perianth to migrate reached its peak at 4.00 a.m. in the morning. Life cycle of coconut mite was determined in the laboratory and the durations of egg, larva, nymphoysalis, nymph and imagochrysalis were 1.9, 1.9, 1.4, 2.5 and 1 days respectively. Determination of longevity and fecundity is in progress. Fluctuation of the populations of coconut mite and predatory mites in three different areas showed a trend similar to that of previous years. Development of the software for the image processing to count the coconut mites was continued. A survey to determine the crop loss due to coconut mite and a study on the effect of nutrition of the palm on the severity of the damage were initiated.

The determination of suitable positions of the palms for placement of sensor of the electronic device to detect red weevil infested palms was completed. Placement of the sensor on the bases of two lowermost fronds at opposite sides and at the base of the trunk detected the incidence at 100% accuracy.

Artificial inoculation of healthy palms with three fungi isolated from affected tissues of leaf rot disease consistently yielded the fungus *Ceratocystis paradoxa* confirming that it is the major fungus responsible for the disease. The fungicides "contaf" and "folicur" were effective in suppressing mycelium growth and conidia production of *C. paradoxa*. Studies were commenced to determine the effectiveness of these fungicides in field conditions.

The study to understand the population fluctuation pattern of the parasitic nematode, *Radopholus similis* infecting coconut roots was continued. A preliminary study to identify the difference in the components of the cell sap of healthy and Leaf scorch decline affected palms using thin layer chromatography methods indicated a difference between the two. The Division also contributed to the ongoing studies on Rapid decline syndrome.

A total sum of Rs. 2,030,069/- was spent from the coconut CESS for research activities to manage coconut mite. A sum of Rs. 205,729/- and Rs. 1,117,744/- was incurred as recurrent and capital expenditure for research from the consolidated fund respectively. A total amount of Rs. 1,968,381 was spent on research activities of the DFID project. Division received contractual research grant from CARP worth of Rs. 2.5 M to work on a collaborative research project on control of coconut mite with Peradeniya and Ruhuna Universities.

2.5 Plant Physiology

Total allocation of funds for Plant Physiology Research as recurrent expenditure and capital expenditure from the consolidated fund was Rs. 1,736,000/- and Rs. 1,282,000/- respectively. A Contract Research Grant worth Rs.2 million was received from the CARP to work on disease an unknown etiology.

Field evaluation of embryo-cultured coconut plants (screened for drought tolerance using PEG), using physiological and biochemical traits was started at Lenawa. A new experiment was commenced at Bandirippuwa Estate to determine the effect of environmental variations, specially rainfall, duration of drought periods and temperature, on the development of coconut fruit components. With the financial assistance of (START), an experiment was started to determine the effect of atmospheric CO_2 increase (doubling the current concentration) on the shoot and root growth, gas exchange capacity, assimilate partitioning pattern and water use efficiency of coconut. Physical and chemical properties of soils in the major coconut growing areas, the respective coconut yields and climatic data were collected to develop crop models for different Agro-Ecological Regions (AER) and Land Suitability Classes (LSC).

The research work on development of the coconut root system was strengthened. The root growth of young seedlings in different LSC and its impacts on physiological performance of the plant is being evaluated. Amputated seedlings are being used in a hydroponics system to evaluate the effect of micronutrient deficiency on the growth of roots, shoot and physiological performance of coconut seedlings.

The feasibility 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) is being evaluated for increasing the productivity of coconut plantations. The protocol for quality preservation of tender king coconuts for a period of one month was obtained by 20 growers/ exporters during the year. Vacuum packing and cold storage (13-15 °C) of Benlate (0.6 g / L) treated tender coconuts was identified as a suitable protocol for extending shelf life of king coconut up to 38 days for export purposes.

The Food and Agriculture Organization (FAO) assisted financially to test whether Coconut Rapid Decline (CRD) is associated with phytoplasma, virus or viroids. Different plant parts such as roots, leaves, inflorescence, trunk borings and heart tissues of healthy and affected palms were tested. No evidence was found for the association of phytoplasma, virus or viroid with CRD disorder. Common salt (1 kg / palm / year, surface application in the manure circle) and Oxytetracycline (OTC, 5g / 5ml / palm or 2.5g / 5ml / palm, trunk injection at four monthly intervals) were found to be effective in improving the total canopy area and gas exchange parameters of CRD affected palms, and further research is needed to test the consistency of these treatment effects. The leaf spraying was found to be a better method of applying nutrients on Leaf Scorch Decline (LSD) and Tapering Disorder (TD) affected coconut palms, compared to root feeding, trunk feeding or axil feeding. Therefore, LSD and TD affected palms in Coconut Research Institute Research Stations and some private estates were sprayed with complete nutrient solution (macro and micro nutrients) at three-monthly intervals and the recovery of the palms is being determined.

2.6 Tissue Culture

The total investment for Tissue Culture research programme as recurrent and capital expenditure during the year, were Rs. 915,000/- and Rs. 1,125,000/- respectively. The Division placed much emphasis on the germplasm exchange programme. Embryos of 10 coconut varieties namely, Kar Kar Tall, Markham Valley Tall, Renell Tall, Gazell Peninsula Tall, Thalasia Semi Tall, PNG Brown Dwarf, PNG Yellow Dwarf, Malayan Yellow Dwarf, Malayan Red Dwarf, Niaz Yellow Dwarf were brought from Papua New guinea (PNG) in August. These embryos were cultured and maintained under *in vitro* conditions. One hundred and eighteen plants raised from embryos (of 4 coconut varieties) brought from India were transferred to soil and over 100 plants are still growing in culture media.

A total of 162 dikiri embryos were cultured during the year and 148 plants were acclimatized. Over 70 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.

Twenty-one tissue-cultured coconut plants were planted at Bandirippuwa Estate to evaluate their performance in the field. 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 two of them (field planted at Bandirippuwa Estate 1999) came into bearing. No abnormalities in vegetative growth or nut characters were observed in these palms. Microsatellite markers were used for testing genetic fidelity of clonal coconut plants already established in the field. Thirty-one tissue-cultured coconut plants of 7 clones were analyzed and no variations were observed within a single clone.

The attempts to induce secondary embryogenesis in immature embryo and plumule-derived callus were unsuccessful. A study on the effect of epibrassinolide (a novel plant growth regulator) on callogenesis and somatic embryogenesis in plumule and immature inflorescence explants was initiated.

Highly friable callus was obtained from *in vitro*-cultured endosperm tissues and attempts were made to initiate cell suspensions using this material. A preliminary study revealed the presence of oil in immature endosperm-derived callus.

Studies on biochemical markers were continued to find any correlation between the biochemical characteristics of immature inflorescence explants and their morphogenic

potential. The contents of total sugar and starch were determined in inflorescences of 5 developmental stages (–5 to –9 stages, considering the youngest open inflorescence as 0). The results revealed accumulation of higher total sugar content in –5 to –7 stages compared to other developing inflorescences that might have some significance on morphogenesis, as these developmental stages also gave rise to a higher callusing frequency. Analysis of sugar profiles of inflorescence tissues of different maturity stages is underway to generate more information on biochemical markers.

A detailed histological study on inflorescence development was undertaken to aid in selecting the most suitable stage of immature inflorescence explants for *in vitro* culture. The study generated important information on floral bud initiation and their subsequent development.

Investigations on anther and unfertilized ovary culture for the production of double haploid plants were continued. Histological analysis of callus and somatic embryos derived from unfertilized ovaries revealed that these structures have originated from diploid tissues (carpels).

Preliminary investigations on micropropagation of papaw (*Carica papaya*) were initiated.

2.7 Biometry

The total allocation for Biometry research and statistical maintenance as capital and recurrent expenditure from the consolidated fund was Rs. 1,357,000/-and Rs. 546,000/- respectively. 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.

Computerized data based management systems for storing and retrieving data from field experiments, climatology and medical aid scheme of the employees were maintained and updated regularly. A Land Area Network system was established during the year.

Impact of harvesting at monthly intervals

The data collected up to August in the experiment on monthly harvesting at Walpita Estate showed a good promise for monthly harvesting as compared to two monthly harvesting. The monthly harvesting maintained its yield level where as two monthly harvesting showed a decrease over 2002.

National Yield prediction

Relationship between the annual national coconut production and seasonal rainfall (year prior to production year) of the seven Agro Ecological Regions (AERs) in coconut growing areas was investigated. The four seasons considered are: FIM (March to April), SWM (May to Sep), SIM (Oct to Nov) and NEM (Dec to Feb). The results confirm that the NEM and SWM rainfall in coconut growing areas have a significant influence on the national coconut production. An empirical model was developed by incorporating effects of seasonal rainfall to predict the national yield in a given year. The predicted values for the years 2003 and 2004 are 2783 and 2900 million nuts. Thus the year 2004 would be good year for the coconut industry.

Variability of rainfall in coconut growing regions

Seasonal rainfall and temperature were analyzed using 70 years (1932 – 2001) data from 25 locations in the seven agro-ecological regions. (IL1, IL3, DL3, DL5, WL2, WL3, WL4). All the AERs except DL3 and DL5 exhibited a significant decreasing trend in annual rainfall. All regions showed significant increasing trend for both maximum and minimum air temperature. The warming rates are lower than the projected warming rates in other parts of Asia.

The fluctuation of seasonal rainfall in all the regions is highly random. Both maximum and minimum air temperature showed significant increasing trends for all the seasons and regions except IL1. The rate of increasing is higher in wet regions than dry regions. The highest increasing rate was observed during FIM period followed by NEM period.

Variability of onset rains

Rainfall was analyzed on weekly basis in all coconut growing regions to recommend a cropping calendar for coconut growers to plan their cultural practices. The following preliminary results were obtained.

- There are significant shifts of the onset of rains in all AERs.
- There is at least 50% probability that rainfall during weeks 14-16 (1-20 April) would exceed 35 mm in IL1, IL3, WL2, WL3, and WL4 regions.
- There is at least 70% probability that rainfall during weeks 43-45 (21 October – 10 November) would exceed 35 mm in all regions with exception in WL4.

2.8 Coconut Processing Research

The Coconut Processing Research Division continued 12 experiments on product development and quality improvement of existing products. The total expenditure for maintenance of research as recurrent expenditure and capital investment for equipment from the consolidated funds were Rs. 3,336,000/-and Rs. 131,000/- respectively.

A study was carried out to develop a method to preserve grated fresh coconut in the form of "ready to serve" using Combination Preservation Technique. The results indicated that application of this technique on fresh coconut would extend the shelf life by one month at ambient (30^0C+/-2) conditions and by minimum of three months at refrigerated (5^0C+/-2) conditions.

A coconut jam was developed with tender kernel and shelf life of the product is about 06 months. Market potential of this product evaluated in the Chilaw urban area. Results indicated that 95% of the consumers like to buy the product at a relatively low price compared to other jams.

Studies were conducted to develop a snack food product from tender nuts. Process of manufacture was established, however it needs further improvements to develop a marketable product.

Four trials on DC manufacture were conducted at Dunagaha DC mill to evaluate the suitability of cultivars TxT(CRIC60) and DGxT(CRIC65). Results showed that TxT(CRIC60) gave a higher out turn compared to that of DGxT(CRIC65). Chemical composition and sensory properties of DC from these two varieties are being studied.

A study was carried out to check the effect of sodium metabisulphite on preservation and bottling of a mild alcoholic beverage from sap to obtain the keeping quality. The results indicated that beverage samples treated with 150 ppm sodium metabisulphite and pasteurized at 70 ^{0}C for 30 minutes (and at 80 ^{0}C for 20 minutes) could be kept for a period of 6 months at ambient (30 ^{0}C+/-2) conditions to maintain an alcohol content of 8.5 %.

The Ceylon Copra Kiln was modified by experimenting for the use of charcoal powder. Modified kiln improved the yield of No. 1 copra (90%), reduced the Polycyclic Aromatic Hydrocarbon (PAH) level below the accepted level and gave an energy saving. Recommendations are available on the modification to the Ceylon Copra Kiln and on the operation schedules for both dry and rainy seasons.

A survey is being carried out to find out the quality of market available coconut oil. Samples were collected from 4 districts. It was observed that samples collected from almost all the four districts gave bad taste and odour. Samples will be collected from several other districts also. Chemical analyses are being done to check the quality.

Virgin coconut oil and value added virgin coconut oil are being produced with the help of a cold pressing expeller. The oil is expelled at 60^{0}C. Therefore, the natural odour and flavour are retained in the oil. Chemical analyses are being carried out to evaluate the quality and shelf life of oils produced and find the applicability of such oils in food, ayurvedic and cosmetic industries.

Studies are being carried out to find out the usability of defatted coconut residue (oil cake) resulted from cold pressing of coconut oil for human consumption. Oil cake is white in colour, has a blank taste and odour and provides high protein (19.4 %) and sugar content (17.9 %). Therefore this can be used in various food items such as bakery products, desserts, yoghurt and sweetmeats etc.

A dish wash bar and dish wash powder were formulated with grade 3 coconut oil at a very low cost, Rupees ten per 200 g dish wash bar and Rupees twenty five per 1 kg dish wash powder. Chemical and cleansing properties are being evaluated.

The Division continued to provide its services to private sector to improve the quality of coconut oil and to produce marketable coconut-based products by small scale entrepreneurs.

2. 9 Extension Services

During the quarter of the year, the staff of the Division heavily involved in the establishment of mite control demonstrations with bagging of young inflorescences with sulphur dust in different affected regions including Manna and Murungen. Three sessions of Research and Extension Dialogues were conducted at the CRI in March to discuss current field problems and to get familiar with difficulties encountered by the field extension workers in respect of technologies introduced by the CRI. Almost all the field extension staff of CCB actively participated in these dialogues. Difficulties faced by the extension personnel in promoting mite control activities were also discussed.

Mass media was effectively used to educate the stakeholders on technologies available to control coconut mite and red weevil. Two video documentaries were produced on these pest control methods. The institute participated at live television progamme "Kamatha" at two occasions on pest control activities. Several TV news items were also organized highlighting important areas in crop management. A series of newspaper articles were also published on

imported issues in the area of coconut cultivation. The division also conducted several radio discussions.

Due to lack of funds growers could not be supported with expected services under the Persuasive Extension Programme in the year. Under this programme only 18 estates were visited covering the extent of 755 acres. These landowners were supplied with estate development plans based on the potential of their estates.

The series of one-day training progammes conducted by the division with the technical guidance of research divisions was successfully completed. Coconut growers participation for the entire series was over 1100. This series includes seven individual programmes on specific technical subjects on coconut cultivation and estate management. Improvement of technical knowledge and skills of coconut growers and the establishment of researcher-grower linkage are the main objectives of this series. So far the division has conducted this popular series for ten consecutive years.

During the year the institute conducted three seminars for coconut growers in Colombo and Lunuwila on the titles; "Reaching the Production Target of Three Billion Nuts", "Improvement of Productivity of Coconut Lands" and " Coconut Irrigation Technology and Policy". Several training and educational programs were conducted for officials of different departments and institutions, undergraduates and students of higher educational institutions. During the year educational programs were conducted for 11,200 students visited the institute from 98 schools. The divisional staff guided over 40 students to prepare their A Level and O Level projects reports.

During the year under review the institute published Coconut Bulletin, Pol Pawath, two ISNAR reports, Annual Report, Newsletters, several Advisory Circulars in three languages, and seven booklets on different technical areas. The Division undertook most of the printing works of the institute.

The institute participated seven agricultural exhibitions during the year. A significant increase was observed in the number of growers visited the division requesting technical advice for their field problems. The number of inquires received through letters and over the telephone has also shown a significant increase.

Under the proposed restructuring scheme, a decision has been taken to reorganize the activities of the division and change the name of the division as Technology Transfer Division.

2.10 Library Services

Library continued to organize and disseminate information and literature to the scientists of the institute and outside researchers. Due to the lack of staff, routine services of the library were provided with great difficulty.

Literature searches were made on coconut databases to cater to the information needs of CRI staff as well as outsiders.

Selective Dissemination of Contents Pages of journals were provided at the institutional level. Under this service, contents pages of 60 journals received from outside libraries were supplied to staff members. The library supplied content pages of 30 journals to other libraries under the same service.

Procurement of journals to the library was not possible due to diversion of allocated money for other priority areas of the institute.

2.11 Estate Management

The major functions of the Estate Management Division were (a) to facilitate research activities by providing labour, land and material support (b) produce seed nuts and coconuts, (c) providing other plant/animals materials, (d) actively involve in dissemination of technology. These four activities were fulfilled successfully during the year.

From the two seed gardens at Ambakelle and Maduruoya 944,761 seed nuts were issued for National Coconut Planting Programme and majority of the seed nuts were issued to nurseries managed by the Coconut Cultivation Board and revenue of seed nut production was Rs. 11.69 million. In general, 42% increase in seed nut production was experienced compared to the same period of the previous year. During the period green nut production was 28.85 million and majority of these nuts were sold through the CDA Auction.

A program of selling of fresh nuts to SATHOSA and Dedicated Economic Centre at Meegoda was also benefited to reduce consumer price in retail market during December, April 2002/2003. Under this programme 462,599 curry nuts were supplied to the above marketing Institutions. Total value of nut from the seed gardens and research stations was Rs. 38.05 million.

The other sundry income was Rs. 2.58 million giving the cumulative income of Rs. 40.63 million from seed gardens and estates.

The average cost of production (C.O.P) of a nut was Rs. 6.30 while net sale average was Rs. 9.24. The lowest C.O.P. was recorded at Makandura as Rs. 4.09 per nut, and this was supported by high production and uniformity of the coconut plantation.Rainfall was varied from 2,147 mm (121 wet days) in the wet zone to 1570 mm (111 wet days) in the Intermediate/dry zones.

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 T x SR variety. Cultural practices such as husk burying, weeding, contour draining were followed according to the schedule.

All the palms in Seed gardens and Research stations received recommended dosage of fertilizer.

Mite damage at the Maduruoya Seed Garden was considerable and all affected palms were treated separately with neam oil and garlic mixture and subsequently burned engine oil preparation. The reduction of mite damage was observed with the continuation of these treatments. It is targeted to bring down the mite damage to zero by integrated management of pest next year.

According to a decision taken by the Economic Policy Committee of the Cabinet and subsequent order received through the Secretary, Ministry of Plantation Industries entire Makandura seed garden (127 acres) was handed over to the Board of Investment, Kurunegala to establish an Industrial park.

2.12 Administration Division

Establishment Unit:

Establishment Unit is one of the units functioning under the administration Division. The activities of this unit are given below.

No recruitments were made as directed in Administrative Circulars No.14.15 & 16 dated 03 January, 23 August and 1 October 2002 respectively.

The staff strength of the CRI as at 31 October 2003, was 338 and almost 412 daily paid labourers were working in 5 research sub stations and 3 seed gardens.

Total budgetary allocation from the consolidated fund was Rs 128.575 million out of which Rs 101,075 million was under recurrent and Rs 27.5 million under capital expenditure. It was expected to generate 48 million rupees as CRI income to balance the required recurrent expenditure. The details of expenditure including salaries and major expenses are given below:

	(Millions)
a) Staff salaries, labour wages, over time and Board's Contribution for medical aid, Provident Fund and E T F	- Rs.72.39
b) Gratuity for 20 members who left the services of the Institute	- Rs.1.904
c) For welfare activities	- Rs.0.396
d) For local trainings	- Rs.0.100
e) For overseas trainings	- Rs.0.247

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.

b. Soils and Plant Nutrition Division

The Division offered the following services to the stakeholders:

Activity	No. of services Offered
Differential Fertilizer Recommendation	- 172
Land suitability tests for coconut cultivation/surveys	- 24
Inorganic fertilizer analysis	- 179
Organic fertilizer analysis	- 49
Analysis of coir pith samples	- 240

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 550,000 laboratory-bred parasitoids. A total of 3750 pheromone vials were sold and 165 l of monocrotophos was issued to the growers to manage red weevil.

3. Donor funded projects and CESS funded projects

3.1 Donor funded projects

Project Title: **Identification of farmer's varieties (Assisted by Coconut Genetic Resources Network/COGENT)**

Division: **Genetics and Plant Breeding Division**

A survey was conducted with the financial assistance of the COGENT to identify farmer's varieties of coconut in three regions, Galle, Wilpotha and Hettipola with the intention of *in situ* conserving traditional base planting material through community based nurseries. The project was successfully completed and the final report was submitted to the donors.

Project Title: **Molecular pathogen diagnosis of rapid decline affected coconut palms (Assisted by FAO):**

Division: **Genetics and Plant Breeding Division**

Proposed activities of the project were completed and the terminal report was submitted to FAO.

A brief description of the physical progress of the FAO funded project during the year 2003 is given below for the Annual Report, 2003. The details on the expenditure are not available with us.

The Food and Agriculture Organization (FAO) assisted financially to test whether Coconut Rapid Decline (CRD) is associated with phytoplasma, virus or viroids. Different plant parts such as roots, leaves, inflorescence, trunk borings and heart tissues of healthy and affected palms were tested. No evidence was found for the association of phytoplasma, virus or viroid with CRD disorder. The FAO financial assistance was terminated.

Project Title: **Identification of coconuts using DNA markers (Assisted by Institute of Fundamental Studies (IFS) Sweden):**

Division: **Genetics and Plant Breeding Division**

The study is in progress but due to delay in purchasing primers the deadline could not be met. An extension was obtained until 31 January 2004 for completion.

Project Title: **Development of biological and chemical methods to manage coconut mite-*Aceria guerreronis* (CARP funded)**

Division: **Crop Protection Division**

Research
Chemical control

1. Large scale testing of Marshal SC by two application methods (i.e. root feeding and spraying) was initiated in two locations

2. Laboratory testing of mospilan and biflex initiated.

Biology and Ecology

1. Life cycle study is on-going Data on one cycle collected.
2. Digital counting of mites - Software writing is completed. Compatibility to work in Microsoft has to be tested.

Biological control

1. Determined oviposition rate of the predator when fed on the host *T. putriscentiae*
2. Determined performance of the predator on the host collected from breadfruit.
3. Determined the most suitable arena for the breeding of the predator.
4. Initiated breeding the host of the predator to be fed to the predator for the mass production of the predator for field trials.

UNEP/GEF Project on effect of climate change on coconut

The collection of data (climate, yield, chemical, physiological and social) was completed during the year.

Crop x climate models and climate prediction models

Two empirical models were developed to predict annual national coconut production using: (a) seasonal rainfall in the previous year and the two years prior and (b) quarterly rainfall in the previous year. The predicted value for the year 2004 from both models is 2900 million nuts. Crop yields showed a significant response ($p<0.05$) to both sea surface temperature (SST) and sea surface temperature anomalies (SST-A) for current and the previous year. In addition models were developed to predict annual coconut yield and climate variables for IL1 region.

Attempts were made to develop a statistical downscaling model to predict quarterly/seasonal rainfall in coconut growing areas using SST from the Global Climate Models.

CO_2 enhancement on productivity of coconut

An experiment was started to determine the impact of CO_2 elevation on the leaf area development and assimilate partitioning pattern of coconut seedlings. There is a strong positive correlation ($r=0.994$, $p<0.001$) between increase in CO_2 concentration and net assimilation rate of coconut palms. The increase is significantly different ($p<0.05$) between soil moisture status. The variation in growth and assimilation partitioning pattern of coconut seedlings under elevated CO_2 concentrations, pattern of dry mater increase in developing coconuts, water requirement by the coconut palm, response of adult coconut palms to irrigation and soil physical parameters of some coconut growing soils were quantified in order to develop crop models.

Economic impact

Although the influence of climate variability on coconut production has been quantified, its economic value on coconut production has not been estimated. The lower and upper bound of extreme production years with respect to climate variability were decided based on 10% and 90% percentiles of the national production array during 1971 to 2001. The income to the economy in crop shortage extremes varied between US $ 54 million to US $ 73 million. The additional income accrued in crop glut extreme varied between US $ 42 million to US $ 87 million. An empirical Ricardian model was also developed to determine the economic impact of climate change.

The expenditure for 2003 is Rs.1,766,609.51

3.2 Cess funded projects

1) Project: Importation of Coconut Germpalsm

During the year two hundred embryos each from ten varieties of coconuts, Rennell Island Tall, Gezelle Peninsula Tall, Thalasia Semi Tall, PNG Yellow Dwarf, Nias Yellow dwarf, Malayan Red Dwarf, Malayan Yellow Dwarf, PNG Brown Dwarf, and three hundred embryos each from varieties, Kar Kar Tall and Markham Valley Tall were collected from Papua New and brought to Sri Lanka. Most of the collection sites were based at the Cocoa and Coconut Research Institute Gene-bank at the Madang Province. Kar Kar Tall and Markham Valley Tall were collected from Kar Kar Island and from Markham Valley Farm in Morobe Province respectively.

Expenditure during 2003: Rs.1,1449,984.12

2) Project: Survey on quality of coconut oil

Physical progress for 2003: The results revealed that almost all the oil samples collected from four Districts, Kurunegala, Anuradhapura, Kegalle and Galle were adulterated due to the fact that the Iodine value of the oil samples were higher than the SLS standards for grade 3 white oil (7.5-9.5). The moisture and FFA contents of oil samples collected from Kurunegala, Anuradhapura and Kegalle were also higher than the SLS standards. However, the moisture and FFA contents of the oil samples collected from Galle District conform to the SLS standards.

Expenditure for 2003: Rs.133,923.00

3) Deep Ground Water Survey in Kurunegala District

Physical Progress

Hydrogeological surveys have been completed in 24 sites. Permission for the drilling of test and observation wells has been received only for 22 sites out of the selected 24 sites. Two observation wells (Muwankanda and Andigama - A sites) and 6 test well (Muwankanda, Pitiyakanda, Korakahawa, Roysten, Andigama - A and Awaragoda sites) have been drilled. Pumping tests have been completed on 03 wells (Pitiyakanda, Muwankanda and Roysten sites). Five water samples from Pitiyakanda, Muwankanda (02 samples), Roysten and Korakahawa sites have been analyzed.

Financial Progress

Investigations	-	18 Nos.	18 x 16,800.00 =	302,400.00
Test wells	-	06 Nos.	6 x 105,600.00 =	633,600.00
Observation wells	-	02 Nos.	2 x 97,680.00 =	195,360.00
Pump test	-	03 Nos.	3 x 43,200.00 =	129,600.00
Water sample analysis	-	05 Nos.	5 x 3,600.00 =	18,000.00

4) Technology Transfer

Total expenditure of the year is Rs. 338,756.00

Physical Progress

1. Production of video film on coconut mite and red weevil
2. Newspaper advertisements regarding CRI programs
3. Three seminars for coconut growers
4. Hosting CRI Web Site
5. Participation in 4 exhibitions
6. Maintenance, repair and production of exhibits and Audio/visual materials

a) Persuasive Extension Program

Total expenditure for the year is Rs.14,000.00

Physical Progress

Due to financial limitations only 18 estates were visited

b) Managers Training Program

Total expenditure for the year is Rs.177777.00

Physical Progress

Certificates awarded to 25 trainees who have successfully completed their practical training at CRI and private sector estates.

c) Refurbishing of TTTS Building

Total expenditure is Rs.132183.00

Physical Progress

The purchase of CFL bulbs to replace the existing florescent bulbs

Maintenance and repair of the Managers' Training Centre.

4. ACKNOWLEDGEMENTS:

The Co-operation extended by the Acting Deputy Director (Research), Deputy Director (Admin and Fin), Heads Divisions, and staff of the Research and Service Divisions contributed to the successful implementation of annual action plan is gratefully acknowledged.

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

Continued support given by the following organizations is also acknowledged:

- Ministry of Plantation Industries
- General Treasury
- Coconut 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 Personal 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 & Technology Commission (NASTEC)
- Kurunegala Plantations Ltd.
- Central Plantation Crop 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 & Agricultural Organization (FAO)

REPORT OF THE AGRONOMY DIVISION

Head - H A J Gunathilake, PhD

1. SUMMARY

Research Programme on development of improved agronomic practices for: i) increasing coconut production, ii) increasing productivity by intercropping, animal husbandry, fuel wood farming, and studies on economic policy related issues were continued. During the year, 23 field experiments and 5 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 2.1 million.

Two major outside funded projects were the ADB funded; Coconut-based Adaptive Research Project (Rs 2.0 million) and COGENT funded Poverty Reduction in Coconut Growing Communities (Rs 2.8 million).

Mulching with coconut husks around coconut palms proved beneficial on coconut yield in comparison with burring of husks in pits as a short-term measure to overcome drought effects. Burring of husks in pits is economically viable when husks price is lower than Rs. 550 per 1000 husks. Planting of coconut in large size holes (1.3 m x 1.3 m x 1.3 m pits) facilitated early flowering of coconut seedlings (56%) as compared with the seedlings planted in standard pits of 1.0 m x 1.0 m x 1.0 m (16%).

Application of glyphosate at the rate of 3.0 L per hectare has found to be effective for controling control weeds in coconut nurseries and this practice saves Rs, 1,480 for 1,000 coconut seedlings as compared with manual weed control. Moreover, 4.0 L of ghyphosate per ha was economically effective in controlling weeds in mature coconut plantations as compared with slashing and cover cropping.

Bud-grafted cashew performed better than cashew plants raised from seeds and air layering. Although grafted cashew did not show any adverse effect on coconut yield, air layered cashew reduced coconut yield by 12% over no cashew situation, indicating competition between coconut and cashew. Adaptive Research Programme revealed that pineapple and cinnamon were the most economical mid-term and long-term intercrops in coconut lands respectively. Gliricidia- fuel wood farming program was given high priority during the year, because of the high demand by the growers and the industry. Gliricidia was found to be ideal for gassifire technology with 3.5 kg of gliricidia (at 20 % moisture) that is equivalent to 1.0 L of furnace oil. Each Gliricidia tree yielded 5.8 kg of wood per annum and actual yield was 15.0 MT/ha. This yield generated a net profit of Rs 15,000 per ha at Pallama Seed Garden.

The project in assessment of the profitability and sustainability of semi-intensive poultry production system under coconut revealed that raising 75 birds (Breed: CPRS) in coconut smallholdings of ¼ ac could generate a net income of Rs 2,000 per month. This production system with 75 birds is ideal for household women and it needs 2 hours of female labour per day. The study also showed that the coconut land with poultry, yielding 60 nuts per palm per year, has to be supplement only with 500g of MOP to meet the palm nutrient requirement, thus saving the cost of inorganic fertilizer by 80%. In pasture evaluation trials, *B. ruzziensis* is recommended for the smallholder dairy farmers in Low Country Intermediate Zone to be grown under coconut.

Under the development of vermiculture technology, four species of Epigiec worms (*Perionyx sp., Eudrilus sp., Lampito sp.* and *Eiseina sp.*) were collected form the coconut triangle.

For the development of sustainable coconut-based income generating technologies in poor rural communities, three community organizations have been formed on production of high value coconut production such as coconut shell handicrafts, coconut bracts handicrafts, virgin coconut oil, door mats, coir brushes, broom and broom sticks.

A survey of 70 households in Chilaw urban area to evaluate the market potential for virgin coconut oil, coconut jam and bottled candied coconuts revealed that these households are prepared to buy these novel products, even by paying a premium price for virgin coconut oil. This implies that the rural communities could initiate the manufacturing of these products, enabling them an income generating opportunities.

The study to evaluate the export potential of desiccated coconut (DC) from Sri Lanka to Pakistan under Free Trade Agreement (FTA) revealed that the consumer demand for DC in Pakistan is price responsive and is significantly and negatively influenced by consumers' income, implying that the proposed FTA would not likely to expand the DC trade significantly between the two countries.

The pay-back period of the drip irrigated coconut plantation owned by the Mahaweli Coconut Plantation Ltd (MCPL) at Pimburaththewa, calculated using actual and budgeted data, revealed that the plantation takes 11 years to generate a positive net return and 16 years to pay-back the accumulated costs, if the plantation would be continued as a coconut monocrop. The study also revealed that the above two time durations could be shorten to 6 and 9 years respectively, if monoculture coconut model is converted into a more intensive coconut-based intercropping model, implying the necessity of intercropping to make the pay-back period of monoculture coconut to be shorten.

Based on monthly farm-gate and retail market fresh coconut prices during the period from 2000 to 2003, it was revealed that the farm-gate price as a percentage of retail price were 516,173 and 66 respectively in years 2000, 2001, 2002 and 2003, implying that growers receive nearly half to 73 per cent the price paid by consumers on fresh coconuts at retail markets. This means that the price spread among the middlemen in the marketing channel varied between 27 to 49 per cent. It was also found that the margin kept by middlemen was almost the same irrespective of changes in farm-gate prices, indicating that the price gap between retail and farm-gate price has not significantly contributed to inflate the retail price of fresh coconuts.

The economic analysis of shifting form furnace oil to dendro thermal energy by desiccated coconut (DC) industry revealed the followings. The cost saving per 1 kg of DC due to shifting form furnace oil-based energy to dendro thermal energy was Rs. 2.84. If all 40 DC mills that currently use furnace oil energy were to shift to dendro thermal energy, some Rs. 119 million of foreign exchange spent on importation of furnace oil would have been saved while some 3500 rural families would have been benefited by opening up of wood supply opportunities.

In terms of carbon sequestration, the proposed energy shift would accrue an environmental benefit of Rs. 88,301 per ha per year with 2,700 gliricidia plants per ha under coconut.

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 2003, root pruning by disk harrowing (15 cm depth) and application on 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*

Treatments	Nuts/palm/year		
	1997-2002	2002	2003
Control (no fertilizer + no harrowing)	29	27	46
Harrowing + Fertilizer	43	63	56
Harrowing only	37	42	40
Fertilizer only	41	47	49
Significance		**	n.s.
LSD (P=0.05)		12	

In year 2003, the nut yield did not differ significantly among treatments in contrast to the significant differences observed in year 2002 (Table 1). The treatment effects may have been masked by the higher rainfall received during wet months in 2002.

The experiment is being continuing.

H A J Gunathilake, S D J N Subasinghe and 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 2003, seedlings planted according to treatment 5 showed a significant increase in total number of fronds produced. Although not significant, seedlings planted in 1.3 x 1.3 x 1.3 m planting holes filled with husks and soil brought from outside had the second highest number of leaves. However, the number of leaves produced did not significantly differed among treatments in year 2003 as in previous years.

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

Treatments	Total Number of fronds/palm	Number of leaves produced
T_1 1 x 1 x 1 m pit (standard planting hole)	9	4
T_2 1.3 x 1.3 x 1.3 m pit (filled with husk/same soil)	11	5
T_3 1.3 x 1.3 x 1.3 m pit (filled with husk/soils brought from out side)	12	5
T_4 1.3 m wide x 1.3 m deep trench (filled with husk/same soil)	11	3
T_5 T_4 + 20% increased standard density of palms (156/ha)	13	5
Significance	*	n.s.
LSD (P=0.05)	4	

The experiment is in progress.

H A J Gunathilake, H A Abeysoma, I M Thilakaratne and 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* (Kenda) 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 *Swieteria macrophylla* (Mahogani) remained very low as in the previous years.

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)
	2002	2003	2003
T_1 *A. auriculiformis*	35	39	34
T_2 *A. mangium-1*	40	41	37
T_3 *A. mangium-2*	42	44	40
T_4 *Calophyllum elatum*	10	14	11
T_5 *Grewia tilifolia*	14	22	15
T_6 *Macaranga paltata*	40	46	40
T_7 *Gliricidia sepium*	22	23	20
T_8 *Tectonia grandis*	22	27	22
T_9 *Swieteria macrophylla*	16	21	18
T_{10} *Bridella mooni*	25	33	27
Significant	***	***	***
LSD (P=0.05)	4	2	2
CV%	2	13	14

The experiment is in progress.

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

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. However, the site at Bingiriya was abandoned in year 2002 due to difficulties in data collection. In year 2003, there was no consistency in treatment effect on nut yield in the three sites as compared with the previous year. At Minuwangoda, palms with individual husk pits (T_9), common husk pits (T_8) and husk mulching (T_5) showed significantly higher nut yields over the control (T_1). However, there were no significant differences in nut yield among these three treatments as in the previous year, suggesting more or less equal effects from burying of husks in pits and mulching.

In contrast, the effect of husk mulching on nut yield was not significantly different from that of control at the Pallama site, as observed in the previous year. At Pallama, the highest nut yield was recorded in palms with coconut frond mulch (T_2) while the lowest was with husk burial in 1.3 m x 1.0 m trenches (T_7).

There were no significant differences in nut yield among treatments at Hettipola site. The nut yield was generally low at this site compared to the previous year.

Since the results were not consistent with the previous year and among the three sites, the experiment will have to be continued until the treatment effects get stabilized in all the sites.

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

Treatments	Minuwangoda		Hettipola		Pallama	
	97-2002	2003	97-2002	2003	97-2002	2003
T_1 - Control (Standard practices)	40	29	44	41	50	52
T_2 - Mulching with 12 fronds	44	32	50	49	48	53
T_3 - T_1 + 1/3 circle trench filled with same soils	42	33	43	35	45	40
T_4 - T_1 + 1/3 circle trench filled with husk	46	43	43	49	47	39
T_5 - Mulching with husk	49	47	45	39	46	46
T_6 -T_4 + T_5	49	46	45	36	48	41
T_7 - 1.3 x 1.0 m trenches	46	38	44	33	43	38
T_8 - 2.6 x 1.3 x 1.0 m husk pits between two palms	49	48	45	39	44	42
T_9 - 1.3 x 1.3 x 1.0 m husk pits for every palm	44	50	43	42	44	40
Significant		*		n.s.		*
LSD (P=0.05)		15				14

The experiments are in progress.

H A J Gunathilake, S D J N Subasinghe, K D D Appuhamy and E M G Banda

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

T_1 - Pueraria cover + P,K,Mg + Slashing
T_2 - Pueraria cover + N,P,K,Mg + Slashing
T_3 - Pueraria cover + P,K,Mg + Harrowing
T_4 - Pueraria cover + N,P,K,Mg + Harrowing

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

During the year, there were significant differences in yield among treatments (fertilizer mixtures and cover management methods) at Melsiripura experiment, but no significant effect of different treatments on nut yield at Pallama (Table 5).

The experiment is being continued.

S H S Senarathne, M J I Costa, H G Wasantha, W R O Fernando and Y M Chandrasiri

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 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 in two depths (0.5ft and 1.0ft). The major weed species present in these sites were Illuk (*Imperata cylindrica*), Mana (*Panicum repens*), Getakola (*Hedyotis auricularia*), Podisinghomaran (*Chromolaena odorata*), Gadapana (*Lantana camara*) and Nidikumba (*Mimosa pudica*).

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 with the development of Pueraria cover. This 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 showed significant differences during the year in Pallama experiment, but no significant effect of different cultural practices on nut yield in Melsiripura experiment (Table 8). Soil moisture content was significantly higher in Glyphosate applied plots at 1.0 feet level in Pallama experiment. In Melsiripura, there were no significant differences among treatments on soil moisture content at both levels (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	Average 2002	Feb 2003	April 2003	June 2003	Aug 2003	Oct 2003	Dec 2003
T_1 - Un weeded	168	137	166	207	173	179	205
T_2 - Cover crop Pueraria)	135	12	45	25	7	4	0
T_3 - Gliricidia	129	142	128	189	198	111	130
T_4 - Slashing & mulching	126	80	138	278	147	91	143
T_5 - Chemical weeding	32	00	16	40	10	44	56
T_6 - Cattle grazing	147	184	137	196	249	193	173
Significance		***	**	***	**	**	**
LSD (P=0.05)		27.49	60.14	71.29	97.72	80.62	58.36
CV%							

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

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	Average 2002	Feb 2003	April 2003	June 2003	August 2003	Oct 2003	Dec 2003
T_1 - Unweeded	168	137	166	207	173	179	205
T_2-Cover crop (Pueraria)	135	12	45	25	7	4	0
T_3 - Gliricidia	129	142	128	189	198	111	130
T_4-Slashing and mulching	126	80	138	278	147	91	143
T_5- Chemical weeding	32	00	16	40	10	44	56
T_6- Cattle grazing	147	184	137	196	249	193	173
Significance		***	**	***	**	**	***
LSD (P=0.05)		27	60	71	98	81	58

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

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	2001	2002	2003
T_1- Unweeded	72	26	68	46	56	59
T_2-Cover crop (Pueraria)	88	38	87	45	52	61
T_3- Gliricidia	77	38	74	59	49	56
T_4- Slashing & mulching	78	27	81	54	50	51
T_5- Chemical weeding	81	44	97	44	61	78
T_6- Cattle grazing	83	36	75	58	46	53
Significance	ns	ns	*	ns	ns	Ns
LSD (P=0.05)	-	-	15	-	-	-

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)	1.0ft (depth)
T_1 - Unweeded	2.48	3.19	3.12	4.69
T_2 - Cover crop (Pueraria)	2.74	4.31	4.01	5.51
T_3 - Gliricidia	2.48	4.01	3.72	5.22
T_4 - Slashing & mulching	2.29	3.31	3.53	5.34
T_5 - Chemical weeding	1.37	6.24	2.61	5.89
T_6 - Cattle grazing	2.68	3.78	3.92	5.28
Significance	ns	*	ns	ns
LSD (P=0.05)	-	1.46	-	-

The experiment is being continued.

S H S Senarathne, K C P Perera, M J I Costa, B Perera and 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 Table 10 were laid on RCBD with three replicates. Forty seed nuts were established in each plot and 90% of seed nuts has germinated. The major weed species present in this site were Atawara (*Panicum repens*), Nidikumba (*Mimosa pudica*), Kuweni (*Cenchrus echinatus*), Kurunegala Desi (*Tridax procumbens*) and Landesi (*Amaranthus paniculatus*). Treatments were applied according to the schedule. Glyphosate and Glyphosate + Diuron treatments applied plots controlled weeds successfully; hence

weed biomass of those plots was the lowest (Table 10). There were no significant differences of weed biomass of between T_2 and T_3 treatments.

Table 10 : *Weed biomass (g/m^2) at different sampling times as affected by the application different combination of herbicides at Wilpotha*

Treatments	Nov 02	Dec 02	Jan 03	Feb 03	Mar 03	April 03	May 03	June 03	July 03	Aug 03
T_1 - Hand weeding	110	186	54	114	178	86	61	160	54	98
T_2 - Glypho 1.4kg/ha	98	172	0	18	66	0	24	48	12	36
T_3 - Glypho1.4kg/ha+Diuron	120	210	0	12	18	0	0	12	3	18
T_4- Glypho 1.4kg/ha+ Oxyflu	104	190	34	48	96	78	96	120	25	48
T_5 - Unweeded	108	194	220	178	238	248	216	186	213	196
Significance	ns	ns	**	**	**	***	**	***	**	**
LSD (P=0.05)	-	-	62	86	112	125	116	157	186	123

Treatments were applied in December 2002, March 2003 and June 2003.

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 Glyposate + Diuron treated plots (T_3) showed higher seedling girth than in the other treatments (Table 11). Unweeded and hand weeded treatment plots showed higher growth rate (seedling height) than that of the other treatments (Table 12).

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

Treatments	March 03	April 03	May 03	June 03	July 03	Aug 03
T_1 - Hand weeding	6.7	7.5	9.2	10.2	10.9	11.7
T_2 - Glypho 1.4kg/ha	6.7	7.6	9.3	10.2	10.8	11.8
T_3 - Glypho1.4kg/ha+Diuron	7.1	8.1	10.2	10.7	11.7	12.8
T_4 - Glypho 1.4kg/ha+ Oxyflu	7.0	7.8	9.3	10.0	10.8	11.1
T_5 - Unweeded	6.5	7.5	9.0	9.9	10.4	10.7
Significance	ns	ns	ns	ns	*	*
LSD (P=0.05)					1.1	1.2

Table 12 : *Effect of different weed control treatments on the growth of coconut seedlings (expressed as the seedling height (cm)) at Wilpotha*

Treatments	March	April	May	June	July	Aug
T_1 - Hand weeding	51	65	85	96	106	119
T_2 - Glypho 1.4kg/ha	49	61	78	87	98	107
T_3 - Glypho1.4kg/ha+Diuron	47	61	76	90	103	115
T_4 - Glypho 1.4kg/ha+ Oxyflu	47	61	80	92	103	112
T_5 - Unweeded	49	70	93	103	114	122
Significance	ns	*	*	*	*	*
LSD (P=0.05)		5	10	9	10	10

Experiment was terminated.

S H S Senarathne, K C P Perera and 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

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

During the year, cashew yield of all treatments were dramatically reduced due to Helopeltis attack. Bud-grafted, air-layered and seedling cashew yields were 0.9, 0.78 and 0.75 kg/tree respectively and 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 year 2002 (Table 13).

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

Treatments	Coconut yield (nuts/palm/year)	
	2002	2003
Coconut monoculture	68	65
Bud grafted cashew	60	61
Air-layered cashew	54	55
Seedling cashew	68	60
Significance (P=0.05)	n.s	n.s.

The experiment is in progress.

H A J Gunathilake and 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 in progress.

H A J Gunathilake, H G Wasantha and B Perera

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 mean 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 in progress.

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

Experiment 21.5.1: Development of smallholder dairy farming under coconut

This experiment was initiated with the following objectives.

i. On-farm evaluation of the performance of recommended pasture varieties in different Agro- climatic regions
ii. Evaluation of farmer perceptions on different pasture varieties
iii. Demonstration and evaluation of different sustainable smallholder feeding systems for livestock in coconut-based farming systems

Three pasture varieties were evaluated on-farm, in the Low Country Wet and the Low Country Intermediate for their suitability for smallholders in terms of dry matter (DM) production, adaptability and farmer preference. Initially, 8 farm models (5 in Low Country Intermediate Zone and 3 in Wet Zone) were established. Each model had at least 2 pasture varieties but in separate blocks. Pastures were fertilized with Urea (50 kg/ac), MOP (25 kg/ac), Saphos Phosphate (25 kg/ac) split in two equal doses. Coconuts were fertilized with APM (3 kg/palm) except control palms.

Productivity of pastures in different agro-eco zones

In Low Country intermediate Zone, *B. brizantha* showed significant (P<0.05) increase in DM production in comparison to *B. miiliformis* and *B. ruzziziensis* (Fig. 1).

Although there was no significant difference in annual DM production between *B. miiliformis* and *B. ruzziziensis* in the Intermediate Zone, monthly distribution of DM production showed that *B. ruzziensis* out yield *B. miiliformis* during dry months of the year (Fig. 2). But the higher DM production of *B. miiliformis* during wet months resulted in higher annual DM production showing a "compensatory growth' under favorable moisture regime. Therefore, results suggest that a mixture of *B. ruzziziensis* and *B. miiliformis* (in the same field but separately) ensures a sustainable feed supply for smallholders in the Intermediate zone. Average Crude Protein content of *B. miiliformis, B. ruzziziensis and B. brizantha was* found to be 12.4%, 12.0% and 12.5% respectively during dry period (Table 16).

Of the three varieties, *B. miiliformis* performed well in smallholdings in Low Country Wet Zone (Fig. 1). Data were not statistically analyzed in case of Low Country Wet Zone due to insufficient replication, as some of the farm models were recently established in Wet Zone.

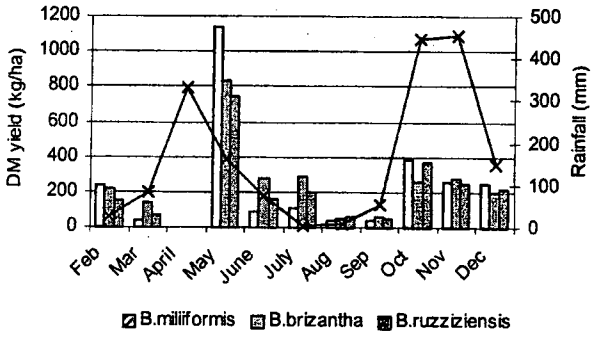


Fig. 1 : *On-farm performance of pasture varieties in (Low Country) Intermediate zone*

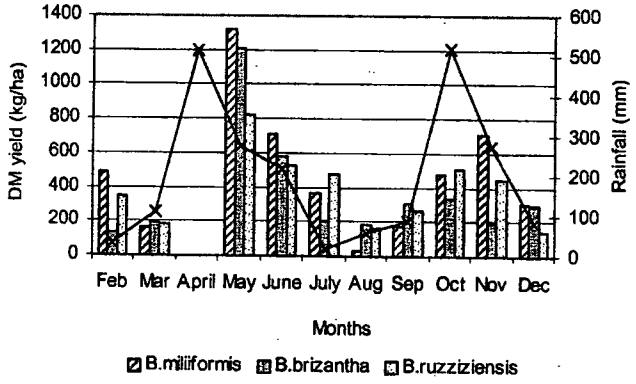


Fig. 2: *On-farm performance of pasture varieties in Wet zone*

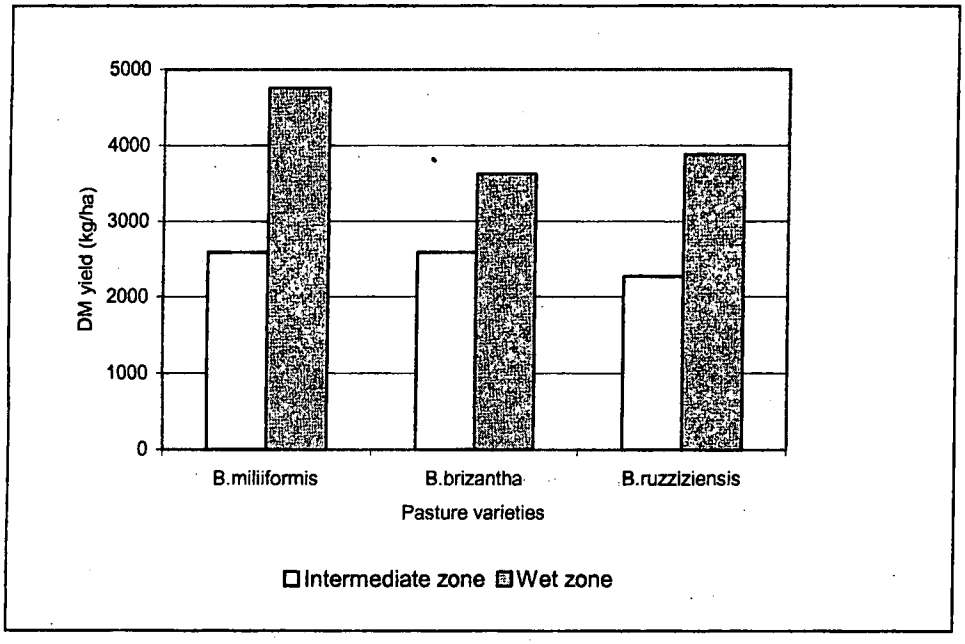


Fig. 3 : *Annual DM yield of pasture grasses in different agro-ecological zones.*

Table 16 : *Crude Protein contents of pasture varieties in farmer fields (Mean ± SD)*

Pasture variety	Crude Protein content (%)
B. miliiformis	12.42 ± 4.19
B. brizantha	12.54 ± 2.61
B. ruzziziensis	12.04 ± 1.12

Farmer perceptions on qualities of different pasture varieties

Farmer preferences on different qualities of pastures such as palatability, drought resistance, defoliation interval and lodging were evaluated. Farmers were asked to rank the different qualities of pastures and percentage responses with respect to each character were calculated.

Palatability of pastures was higher in case of *B. miliiformis* and *B. ruzziziensis*. Farmers prefer *B. miliiformis* and *B. ruzziziensis* to *B. brizantha* since higher rate of wastage of feed due to hard stems in *B. brizantha*. Regeneration capacity after defoliation was higher in *B. miliiformis* and *B. ruzziziensis* in comparison to *B. brizantha*.

Results suggest that the combination of *B. miliiformis and B. ruzziziensis* can be recommended for smallholder dairy farmers in the Wet Zone.

Effect of pastures on yield of coconut

Results show that the impact of pasture on coconut yield can be reduced when the pasture and coconut are fertilized regularly (Table 17).

Table 17 : *Effect of pasture on yield of coconut (with and without fertilizer application for coconut) (Mean ± SD)*

Treatment	Coconut yield/palm/year				
	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5
Coconut - fertilized *	47.1±13.9	16.5± 10.3	31.5± 13.0	61.2± 6.6	26.6±8.7
Coconut - not fertilized	33.8± 14.1	24.3±18.6	18.8± 8.0	33.1±23.0	22.5±12.4

* Yield of coconut with fertilizer application was significantly different (P 0.001) from that of without fertilizer application (37.5 vs. 27.8)

Experiment was terminated.

A D Samarajeewa and M D V Saparamadu

Experiment 21.5.3 : Development of a low cost poultry production system under coconut

This experiment was designed to assess the feasibility, profitability and sustainability of semi-intensive systems under coconut and to assess the nutrients balance of the coconut-poultry system under restricted scavenging systems. Three chicken crosses/strains were evaluated for the production and adaptability for restricted scavenging system in coconut lands with the supplementation of formulated ration by half the rate of the requirement. The CPRS Brown developed at the Central Poultry Research Station (CPRS), Kundasale was mated to indigenous chicken collected from different parts of Sri Lanka. The need was not only egg production but also to retain the ability to brood by this upgraded bird. Two upgraded populations with 50% indigenous blood levels (I50) or F1, and 75% indigenous blood levels (I75) or B1 were produced. These two populations and a commercial strain (CPRS Brown) were then evaluated under coconut in restricted scavenging system. One-month-old chicks were introduced into the system. They were allowed to scavenge within the enclosure (16m^2 per bird) but were supplemented with a formulated ration. Formulated poultry ration was consisted of 14.45% Crude Protein, 2684 Kcal/kg Metabolic Energy, 0.7% Lysine and Methionine + Cystine 0.48%.

Comparison of the productivity of different poultry strains/breeds

a. Growth rate

Table 18 : *Growth rates of different poultry strains tested*

Breed		Growth Rate (g/day)		
		24 week	38 week	45 week
CPRS	Mean	8.77^a	5.67^a	4.82^a
	SD	1.02	0.42	0.41
	CV%	11.7	7.4	8.6
I 75 (B1)	Mean	7.20^b	4.77^b	4.01^b
	SD	0.86	0.46	0.52
	CV%	11.9	9.6	12.9
I 50 (F1)	Mean	7.28^b	5.17^b	4.37^b
	SD	0.92	0.57	0.52
	CV%	12.7	11.0	11.9

a, b, within a column is significantly different, P< 0.05

Growth rate and Body weight

The growth rate of CPRS was significantly different (P< 0.05) from I 50 and I 75 (Table 18). The early body weights show a faster growth of the selected CPRS Brown strain, but the I 75 took a longer time (49 week) to pass 1500 grams body weight even though they consumed almost the same amount of feed. Whereas I 50 growth started slowly, and after 45th week it was closer to CPRS Brown body weights.

b. Egg production

Hen Housed Production of CPRS Brown is higher (216.3 eggs) than I75 and I50, which has produced 185.7 eggs and 180.7 eggs respectively for the period of 68 weeks production.

Table 19 : *Egg production of different crosses*

Breed	Egg production (68 weeks)	Average feed Consumption (g/day/bird)
CPRS	HD* 44.9%[a]	78.7
	HH** 43.9%[a]	
I 75 (B1)	HD 38.5%[b]	80.5
	HH 32.3%[b]	
I 50 (F1)	HD 37.5%[b]	81.6
	HH 33.9%[b]	

a, b, within a column is significantly different, P< 0.05
*HD- Hen Day Production ** HH- Hen House Production

The selected strain CPRS Brown had the ability to continue till the 60th week of production without a drop. During this period, there have been periodic drops in production, especially at 25-30 week and 40 week. However, the drop in egg production in CPRS Brown was less compared to other two types. This can be attributed to the early body weight growth in the CPRS Brown.

The egg weight was also higher in case of CPRS (53.8 ± 1.2 g) in comparison to I 75 (45.9 ± 3.9 g) and I 50 (48.8 ± 2.5 g).

Nutrient balance of the coconut - poultry system

Nutrient flows of the different coconut poultry systems (I75, I50 and CPRS) were given in Annual Report 2002. Feed for poultry (50% of the requirement), chicks and deposition were the major source of nutrient inputs to the system while eggs, weight gain of birds, removal of coconuts, volatilization, leaching and run off were the nutrient outputs of the system. Removal of nutrient by the coconut leaves and droppings of birds were considered to be recycled within the system. N volatilization was estimated as 8-10 % of the total input. Leaching and runoff were assumed as 10% of total nutrient input (N).

The systems show a positive balance of Nitrogen (133-170 kg/ha/yr) and Phosphorous (27-77 kg/ha/yr) while Potassium is in negative balance of 46-49 kg/ha/yr. Leaf and soil nutrient contents (Tables 20 and 21) also confirm the positive effects of poultry on coconut.

Table 20 : *Leaf nutrient contents*

Treatments	N (%)	P (%)	K (%)
With poultry	1.8 ± 0.13	0.15 ± 0.01	1.3 ± 0.14
Without poultry (Control) Treated with inorganic fertilizers	1.9 ± 0.05	0.14 ± 0.01	1.2 ± 0.20

Table 21 : *Soil nutrient contents*

Treatment	Location and depth of soil	N (ppm)	P (ppm)	K (ppm)
With poultry	Coconut basin * - 15 cm	459 ± 64	338 ± 165	1.124 ± ..02
	- 30 cm	353 ± 69	202 ± 76	0.165 ± 0.02
	Coconut inter rows - 15 cm	352 ± 43	275 ± 109	0.141 ±0.03
	- 30cm	391 ± 108	197 ± 39	0.134 ±0.03
Without poultry (control)	Coconut basin * - 15 cm	415 ± 12	34 ±9	0.105 ±0.007
	- 30 cm	307 ± 53	48 ± 19	0.094 ± 0.003
	Coconut inter rows - 15 cm	326 ± 5	24 ± 5	0.116 ±0.005
	- 30cm	276 ±6	29 ±8	0.134 ± 0.006

The study shows the total Nitrogen and Phosphorus requirement (Nut production- 90 nuts/year/palm) are provided through the inputs and by products of poultry. Potassium requirement has to be supplemented through external inputs at the rate of 1 200 g of MOP per palm per year. But for coconut lands with 60 nuts per palm per year, supplementation of 500 g of MOP is sufficient to meet the palm nutrient requirement thus saving the cost of fertilizer by 80%.

Effect of poultry droppings on improvement of soil biological properties

Table 22 shows the effect of droppings of poultry on soil biological properties. Plots with poultry showed improved biological activity in comparison with control plots.

Table 22 : *Microbial activity of soil in the coconut basin of the palms with poultry without poultry*

Treatments	Microbial Activity - CO_2 evolution (µg/g of soil/hr)
With poultry	8731.0 ±1422.5
Without poultry (Control) Treated with inorganic fertilizers	5938.2±826.6

Project revealed that raising 75 birds (Breed: CPRS) in coconut smallholding with ¼ ac of coconut generate the net income of Rs. 2000.00 per month. This production system with 75 birds is ideal for household women and it needs 2 hours of labour per day. Cost benefit analysis for different scenarios is given below.

Further studies will be carried out enhancing the CPRS blood levels to 67.5% in order to increase the egg production and to ascertain the impact on poultry production system on soil fertility in the long run.

Cost and Benefit analysis for poultry production system under coconut

(For the smallholder system with 75 birds (CPRS))

Scenario 1 - Without valuing the family labour
(Assuming that no opportunity cost for family labour)

Costs	**Rs. Per batch (1.5 yrs)**
Chicks (75 @ Rs.35 each)	- Rs. 2 625.00
[1]Feeds (Rs.13.30/kg for formulated ration)	- Rs. 30 130.00
[2]For housing (40% per year)	- Rs. 4 500.00
Feeding/water troughs	- Rs. 600.00
Vaccines/medicines	- Rs. 1 965.00
Fencing (with Gliricidia)	- Rs. 1 000.00
Total Cost	***- Rs. 40 820.00***
Benefits	
Sale of eggs (12510 x Rs. 5.00)	- Rs. 62550.00
[3]Sale of birds	- Rs. 13600.00
[4]Savings from fertilizing coconut palms	- Rs. 1620.00
Total Income	***- Rs. 77770.00***
Profit	**- Rs. 36950.00**

- Profit per month is around Rs. 2000.00 as there is a lag period of five months. This production system with 75 birds is ideal for household women and it needs 2 hours of labour per day. Profit is calculated assuming that there is no opportunity cost for women labour.

1. Feed is formulated with low cost materials available locally.
2. Total cost for house for 75 birds is Rs.7500.00, which will last for 2.5 years.
3. Sale of birds after laying period each at Rs.200. 10% of motility is assumed.
4. Dung from 75 birds is equivalent to 20 kg of Nitrogen, 5.6 kg of Phosphorus and 27.8 kg of Potassium which is sufficient to fertilize area needed to confine 75 birds (18 coconut squares)

Scenario 2 - Family labour is valued at market wage rate

(Assuming that there is an opportunity cost for family lablour)

Costs	**Rs. Per batch (1.5 yrs)**
Chicks (75 @ Rs.35 each)	- Rs. 2 625.00
[1]Feeds (Rs.13.30/kg for formulated ration)	- Rs. 30 130.00
[2]For housing	- Rs. 4 500.00
Labour (1 hr/day x 548 days @ Rs.200 / man day)	- Rs. 13 700.00
Feeding/water troughs	- Rs. 600.00
Vaccines/medicines	- Rs. 1 965.00
Fencing (with Gliricidia)	- Rs. 1 000.00
Total Cost	**- Rs. 54 520.00**

Benefits

Sale of eggs (12510 x Rs. 5.00)	- Rs. 62 550.00
[3]Sale of birds	- Rs. 13 600.00
[4]Savings from fertilizing coconut palms	- Rs. 1 620.00
Total Income	**- Rs. 77770.00**
Profit	**- Rs. 23250.00**

* Profit per month is Rs. 1300.00 as there is a lag period of five months. This production system with 75 birds is ideal for household women and it needs 2 hours of labour per day. Profit is calculated assuming that there is an opportunity cost for women labour.

The experiment was terminated.

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PROJECT 24 : STUDY ON IMPACT OF TRADE AGREEMENTS ON COCONUT INDUSTRY

Study 24.1 : Evaluation of the export potential of desiccated coconut under the Sri Lanka-Pakistan Free Trade Agreement

The proposed Sri Lanka- Pakistan Free Trade Agreement (FTA) includes a gradual duty phasing out for agricultural commodity trade between the two countries. Tea, natural rubber, vegetable products, coconuts, dried fruits and spices are the main agricultural commodities exported to Pakistan from Sri Lanka. Fresh coconuts, copra, Desiccated Coconut (DC) and coconut oil are the main coconut-based products exported to Pakistan during the past decades. DC is the major export product that earns higher foreign exchange among the coconut products. Hence, this study aimed to assess the Sri Lanka's export potential of DC to Pakistan under the FTA between the two countries.

The consumer demand for DC in Pakistan and the export demand of DC in Sri Lanka were estimated using regression analysis. Results are given in Tables 23 and 24.

Table 23 : *Regression results of export demand of DC at Pakistan*

Variable	Estimated Coefficient	t-Statistic	P value
Constant	445.48	0.58	0.570
Export price of DC in Sri Lanka	- 13.71	- 1.74	0.097*
DC price in Pakistan	- 261.75	- 1.74	0.097*
Time trend	1.39	2.47	0.023**

** Significant at 5%, Significant at 10%, R^2=0.60

Table 24 : *Regression results of the import demand of DC in Pakistan*

Variable	Estimated Coefficient	t-Statistic	P value
Constant	0.299	0.98	0.337
Price of DC at Pakistan	-1.09	- 2.05	0.055**
Per capita income of Pakistan Consumer	- 5.93	- 2.207	0.040*
Time trend	- 0.31	- 0.26	0.799

** Significant at 5%, Significant at 10%, R^2=0.60

The results indicated that the price responsiveness of per capita demand of DC at Pakistan is higher. This suggests that the FTA has positive impacts on the DC exports from Sri Lanka to Pakistan. However, the per capita income effect on DC consumption at Pakistan is negative. Therefore, the DC consumption tends to decline with rising per capita income. This indicates that the affluent consumers in Pakistan consider DC as an inferior commodity. Therefore, the net effect of these two factors will judge the potential of DC trade between the two countries under the FTA in future. Also, the export quantity of DC to Pakistan by Sri Lanka is determined by the free on board (fob) price of DC and the domestic price of coconuts. Both these factors have significant negative relationships with the export quantity of DC to Pakistan. This implies that the DC exporters in Sri Lanka tend to prefer other destinations rather than exporting to Pakistan when there is a world price hike for DC. Hence, the proposed FTA between the two countries will not make significant changes on the quantity of DC export by Sri Lanka to Pakistan.

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PROJECT 26 : ECONOMIC STUDIES ON MARKETING ISSUES

Study 26.1 : An analysis of gap between retail and farm-gate prices of coconuts

A steady decline was observed in farm-gate price of coconuts from January to May 2003, but this decline was less reflected in retail price during the same period implying that the consumers were less benefited than expected from the observed farm-gate price fall.

Motivated by the above observation, this study aimed to investigate the influence of gap between monthly average retail and farm-gate prices of coconuts in pushing the retail market coconut price up.

Monthly farm-gate and retail market coconut price data for the period 2000 to 2003 were collected from the published sources.

Table 25 shows the gap between monthly average retail and farm-gate prices of coconuts and the monthly average farm-gate prices as a percentage of monthly average retail prices.

Table 25 : *Gap between retail and farm-gate prices of coconuts (2000 - May 2003)*

Month	Year							
	2000		2001		2002		2003	
	Gap (Rs/nut)	Farm-gate price as a % of retail price	Gap (Rs)	Farm-gate price as a % of retail price	Gap (Rs)	Farm-gate price as a % of retail price	Gap (Rs)	Farm-gate price as a % of retail price
January	3.70	64.4	4.08	50.1	5.03	68.9	3.23	79.1
February	3.46	65.7	4.12	53.9	6.25	62.0	3.9	74.5
March	4.02	58.1	4.46	51.8	4.16	71.7	4.92	67.7
April	4.63	50.9	4.54	49.8	4.66	67.3	5.58	61.2
May	4.42	51.6	4.06	52.6	3.76	72.7	6.65	52.6
June	5.02	43.0	3.03	64.7	2.79	79.8		
July	4.51	47.1	1.51	80.3	2.76	80.4		
August	3.82	54.7	3.40	64.8	2.96	79.1		
September	4.37	50.1	3.42	68.9	3.30	77.6		
October	4.38	48.8	4.41	62.9	3.75	74.5		
November	4.71	45.4	3.75	69.1	4.69	69.8		
December	4.61	43.4	4.73	67.7	4.14	73.5		
Geometric average		**51**		**61**		**73**		**66**

According to Table 25, farm-gate price as a percentage of retail price is 51, 61,73 and 66 respectively in years 2000, 2001 and 2002 and during the first five months of 2003. This means that the growers received nearly half to 73 per cent the price consumer paid on coconuts at retail market during the analysed period. So the price spread among the middlemen in the marketing channel varied between 27% and 49%.

There is no any value addition along the marketing channel, i.e. coconuts go to the hands of the consumers in the same form they have been harvested. In such a situation, it is usually expected that a greater share of the consumer price goes to the primary producer, the grower. However, it has not happened in year 2000 as evidenced by this analysis. In year 2001 however the share of retail price received by growers has increased to 61% and it has further increased to 73% in 2002 followed by a drop to 66% in 2003.

This shows that the share of retail price received by growers has been changing over the years, which prompted us to examine the relationship between the farm-gate price of coconuts and the share of retail price received by growers (Figure 4).

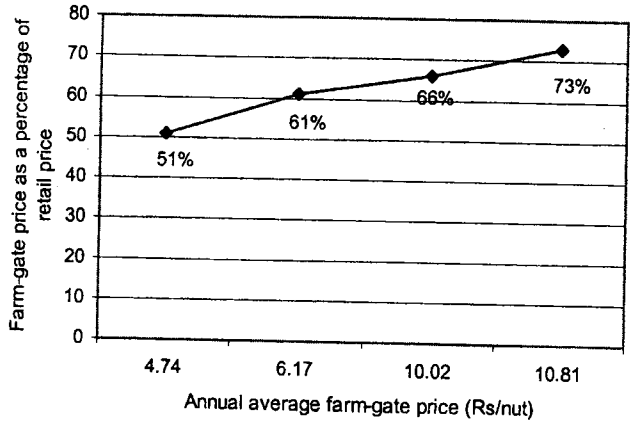

Fig. 4 : *Relationship between farm-gate price and share of retail price received by growers*

Figure 4 shows that the share of retail price received by growers increases with increase in farm-gate price. This means that a greater share of price paid by consumers at retail markets goes to growers' hands when farm-gate prices are relatively higher. Implicit in this finding is that the gap between retail and farm-gate price does not widen proportionately with the increase of farm-gate prices.

Although there is no strong discernible relationship between absolute price gap and the farm-gate price of coconuts (Figure 5), the gap tends to be fluctuating in a very narrow range in response to changes in farm-gate price. This further supports our earlier contention that the margin kept by middlemen is almost the same irrespective of farm-gate prices.

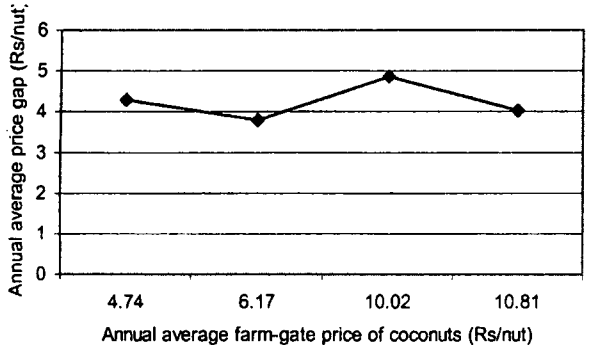

Fig. 5 : *Gap between retail and farm-gate price in relation to farm-gate price*

It may also be worthwhile to examine the relationship between price gap and the retail price. As Figure 6 shows, retail price has not consistently increased with the increase of price gap. So, the price gap alone has not proved to contribute for raising the retail price.

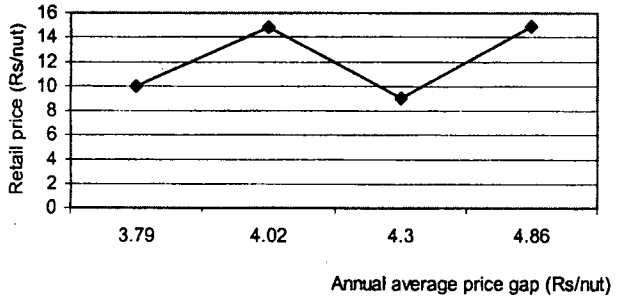

Fig. 6 : *Influence of gap on retail price*

In summary, the gap between retail price and farm-gate price was found to be varying in a narrow range at any farm-gate price of coconuts during the analysed period, except in 2002. So, the price gap appears to have not inflated the retail price significantly in 2000, 2001 and first five months of 2003 but have done so in 2002.

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Study 26.2 : Assessment of the market potential for new coconut-based products

Recent market trends show that there is a decline in demand for traditional coconut-based products, while a range of non-traditional coconut-based value added products have emerged in the domestic as well as in the international markets. The virgin coconut oil, coconut jam and bottled candied coconuts are a few of the new coconut-based products manufactured in Sri Lanka as outcomes of recent research and development activities. The marketability of any new product is an important factor for survival of the enterprise and to make profits to the manufacturers. The consumer acceptance of the product is one of the major factors in marketing of the new product. Hence, a preliminary market survey was carried out using 70 households in the *Chilaw* urban area to assess the marketability of these new coconut-based high value products. The specific objectives were to evaluate the consumers' acceptability and preferences of the selected new coconut-based products, i.e., virgin coconut oil, virgin king coconut oil, coconut jam and bottled candied coconut for better marketability and to obtain consumers' suggestions for product development.

The results of the market survey indicated that there is a higher market potential for all these new coconut-based products in the specified area. The consumer acceptance for virgin coconut oil and virgin king coconut oil indicated promising market opportunities in this urban area. In addition, a majority of consumers expressed their willingness to pay for virgin coconut oil a premium price above the current market price for bulk coconut oil available in the market. This indicated that the consumers awareness of the purity of the virgin oil and its qualities. Moreover, around 40% of the respondents show their dissatisfaction on the quality of coconut oil they currently buy at the market. Also, there is no known place available for the consumers to buy king coconut oil, when a need arises. Hence, there is a potential market in this urban area for virgin oils.

The respondents have used coconut jam as bread spread as similar to other fruit jams available in the market. Nearly 69% of the respondents claimed that the coconut jam was better or similar in quality as other fruit jams. However, 30% of the respondents suggested that the removal of the oily taste present in coconut jam would be better. Therefore, the producers need to improve the product based on the consumer views for better marketability. Also, 59% of the respondents claim that they prefer a relative lower price for coconut jam than that of other fruit jams. Consumer acceptance for bottled candied coconut was encouraging. Nearly 70% of the consumers willing to buy bottled candied coconuts if it is available in the market and would like to pay around 70 rupees for a bottle contain 450g of candied coconuts.

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PROJECT 27 : STUDIES ON ENERGY ECONOMICS

Study 27.1 : Economic feasibility of shifting from furnace oil to dendro thermal energy in desiccated coconut industry of Sri Lanka: An ex ante environmental economic analysis

Of the 65 DC mills in Sri Lanka, 40 have been modernized recently. Shifting to furnace oil from firewood as the source of energy required for boiler operation constitutes a major component of this modification. The steady increase of furnace oil price has significantly contributed to raise the cost of production (COP) of DC. The gasifier technology, which uses gliricidia sticks as the feedstock, produces dendro thermal energy at relatively lower cost than imported fossil fuel-based furnace oil.

This study analyses: (i) the economic feasibility of shifting from furnace oil-based DC manufacturing to dendro thermal energy-based DC, (ii) the effect of using dendro thermal energy in DC production on C sequestration, (iii) the potential of the energy shift on rural poverty alleviation and finally elicits the millers' perceptions on this energy shift.

Results suggest the followings. The cost saving per 1 kg of DC due to shifting from furnace oil-based energy to dendro thermal energy is Rs 2.84. The mean DC production of the surveyed sample of mills per day was 5.87 tons. So, this energy shift results in an incremental gross margin of Rs 16,702 per mill per day, which is 29% increase of GM with respect to the GM, earned from furnace oil-based energy.

If all 40 DC mills that currently use furnace oil energy were to shift to dendro thermal energy, Rs 119 million of foreign exchange annually spent on importation of furnace oil could be saved. The recent 3% appreciation of Rupee against US$, negatively affect the export competitiveness of the DC industry in the global market place. Reduction of COP due to energy shift was also found to be about 3%. This implies that the energy shift would be able to negate the set back of export competitiveness of the DC due to Rupee appreciation.

In terms of C sequestration, the proposed energy shift would accrue an environmental benefit of Rs 88 301 per ha per year with 2 700-gliricidia plants per ha under coconuts. It was found that some 3 500 rural families are likely to be benefited by opening up of wood supply opportunities, if all 40 DC mills shift to dendro thermal energy. A household can earn an estimated Rs 59.00 a day, which is over half the poverty line income level. So, this energy shift involves a rural poverty reduction contribution as well.

A gasifier approximately costs Rs 3.5 million. The payback period was found to be 210 working days (8 months equivalent). Literally therefore, the initial investment on the gasifier is recovered in less than a year. However, it would take well over a year to payback as DC mills work intermittently as dictated by short supply of basic raw material, coconuts.

The elicitation of millers' perceptions reveal that although they regard this energy shift as an appropriate approach to reduce the COP of DC, the relatively higher initial investment, uncertainty of regular supply of gliricidia wood etc. would discourage them adopting this gasifire technology.

Therefore, government intervention on installing a free demonstration will be a useful effort to promote the dissemination of the technology. This intervention may further be justified in the light of potential foreign exchange saving of Rs 119 million due to the energy shift. Uncertainty of the continuous supply of gliricidia wood is another constraint hindering the acceptance of this technology by DC millers. The strengths of the existing network of the "*Samurdhi*" program of the government, which operates islandwide with the aim of uplifting the income and living standard of the rural poor, may be exploited to assure the continuous supply of gliricidia wood. The active participation of "*Samurdhi*" recipients for cultivation and processing of gliricidia woods may be implemented with the assistance of Divisional Secretaries.

M T N Fernando and K V N N Jayalath

PROJECT 28 : ECONOMIC STUDIES ON IRRIGATION OF COCONUTS

Study 28.1 : Utilization of Cess funds by Mahaweli Coconut Plantation Ltd for cultivation of coconuts under drip Irrigation (Collaborative Study: MPI, CDA, CCB, and CRI)

Expansion of coconut cultivation into new areas and supplementary irrigation of coconuts have been identified as key short-term strategies to achieve and sustain the 3 billion national coconut production by the Coconut Task Force under the "Policy Framework for the Plantation Sector". The Mahaweli Coconut Plantation Ltd (MCPL) has initiated planting of 545 ha coconuts under drip irrigation at Pimburettewa, Mahaweli system B in September 1998 under drip irrigation using coconut Cess funds. An economic analysis was carried out using actual and budgeted data to determine the payback period of this coconut plantation.

Assuming bearing takes place in the 6th year after planting and the plantation attains an optimum yield of 100 nuts per palm per year between 12-15 years after planting, it was found that the monoculture coconut plantation takes 11 years to generate a positive net income and 16 years to pay back the accumulated total costs. The long pay back period is partly because coconut is a less intensive crop and partly because of the heavy capital investment necessitated by the sophisticated irrigation system.

The study revealed that the above two time durations (i.e. 11 and 16 years) could be shorten to 6 and 9 years respectively, if the monoculture coconut model is converted into a more intensive coconut-based intercropping model. This shows that if coconuts are to be expanded in the Dry Zone with sophisticated drip irrigation systems, it is desirable to grow coconut with intercrops to make the payback period shorten.

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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 2003, the total number of adaptive research sites was reduced to 96 with the termination of 16 sites due to poor farmer participation. 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 as follows.

a. Coconut

Coconut yields append to improve in year 2003 as compared to 2002 in almost all the sites. In particular, yield increase in one site in Matara district was 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 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.

b. Banana

In Gampaha district, establishment cost of 1-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 showed promis as a 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 of pineapple.

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 in progress.

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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 dendro-thermal power generation in coconut lands. 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 26.

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.

Table 26 : *Production details of fuel wood plantation, Pallama Seed Garden*

Description	
Number of harvests during the year	2.00
Wood yield Kg/tree/yr	17.70
Total wood yield Kg	133,246.50
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 in progress.

H A J Gunathilake and 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 as a pilot project with the objective of reducing poverty in coconut growing communities through coconut-based interventions, i.e. coconut-based cottage industries, intercropping, livestock keeping etc.

Under the project, total of 155 participants were trained on different activities during the year 2003 on coconut-based cottage industries, intercropping, livestock keeping and management of community-based organizations. Livestock and intercropping programs were initiated with the participation of 155 families. Production of high value coconut products such as coconut shell handicrafts, coconut bracts handicrafts, virgin coconut oil, doormats, coir brushes, brooms and broomsticks have been initialised in 3 communities in order to generate the income of the families in these communities. Trainings, machineries, micro

credit systems, marketing facilities for the production and marketing of coconut based value added products were facilitated through the project. The total expenditure for the year 2003 was Rs. 2,828,732.00.

A baseline survey was carried out among the project participants before the project intervention was done which will be used for the evaluation of the impact of project interventions on livelihoods of participants.

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([1] Coconut Processing Research Division)

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

Based on the results of the bioassay with tomato seedlings, the experiment with coconut seedlings to evaluate the effect of vermi-compost on growth of coconut seedlings was initiated. Following treatments were imposed.

T_1 - Soil with inorganic fertilizer
T_2 - Soil with bio compost
T_3 - Soil with vermi-composts
T_4 - Soil with vermi-compost and vermi-wash (as a foliar application)
T_5 - Soil only (untreated control)

Following data are being collected in order to evaluate the effect of vermi- compost on seedling growth of coconut.

Growth parameters of coconut seedlings, microbial activity of the potting media, rate of nutrient mineralization in the potting media and bio chemical/physiological parameters of seedlings such as chlorophyll content, rate of photosynthesis, stomatal conductance.

A D Samarajeewa, N A Tennakoon[1], C S Ranasinghe[2] and E C L de Zoyza
([1]Soils and Plant Nutrition Division, [2]Plant Physiology Division)

3.5 Evaluation of the potentials and limitations of coconut-based activities for income generation among rural women in Sri Lanka

Women's participation in various coconut-based income generation activities has become insignificant. A study was done to assess the role of women in different coconut-based cottage industries for income generation and to evaluate the potentials and limitations encountered by these rural women. Three coconut-based rural communities were selected at: i) Hettipola (Kurunegala District), ii) Wilpotha (Puttalam District), and iii) Dodanduwa (Galle District) for the study. Data were collected using a pre-tested structured questionnaire, using a random sample of 198 participants in the three selected communities.

Preliminary results of the study reveal that a majority of women in the sample belongs to the age groups of 20-35 years (27%) and, 36-55 (55%). Their education level is fairly standard, where a majority (45%) has got their education up to GCE ordinary level, whereas another 13% of the sample got their education up to GCE advanced level. However, their opportunities for income generation through regular employment or other paid work is minimal as indicated by the daily per capita income generation (Table 27).

Table 27 : *Daily income generation by rural women in coconut-based communities*

Daily per capita income generation (Rs/day)	% of women included in each coconut-based community		
	Hettipola	Wilpotha	Dodanduwa
< 100	67	68	57
< 200	27	25	36
< 300	2	5	7
> 300	4	2	1

Source: Baseline survey of coconut-based communities (2003)

The women in the sample engaged in various coconut-based activities for income generation, i.e. coconut-based farming and animal husbandry, bract handicraft making, coir yarn spinning, weaving of cadjans, cashew nut splitting etc. and other non-regular paid work etc.

The land ownership in each community shows notable variations. Both Hettipola and Wilpotha communities own considerable land parcels, whereas many respondents in the Dodanduwa community are land-less or own very small land parcels. This is reflected by the income generated from fresh coconuts to the total household income in each community (Table 28). In addition, women play an important role in household total income generation in these communities (Table 29).

Table 28 : *Percentage contribution of fresh coconut income to the total annual household income of the communities*

% Contribution by coconut income to the total	Number of households in each community		
	Hettipola	Wilpotha	Dodanduwa
0	23	43	93
< 10	21	11	4
> 10 - < 25	25	18	1
> 25 -< 50	17	6	-
> 50	15	20	-

Source: Baseline survey of coconut-based communities (2003)

Table 29 : *Women's contribution in total annual household income generation*

% of women's income to the total annual household income	% of females
< 10	5
> 10 - < 25	27
> 25 - < 50	40
> 50	5

Source: Baseline survey of coconut-based communities (2003)

S R Samarajeewa and A D Samarajeewa

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

Generally, the coconut-marketing channel consists of a large number of intermediaries at different levels in the marketing process. At each stage, the price for a nut changes depending on the profit margin extracted by each middleman. Another important feature in the coconut-marketing channel is that there is no value addition for the fresh nut throughout the system and it is a homogenous product until in the hands of the final consumer. Hence, a greater share of the consumer price of fresh coconuts is supposed to go to the primary producer excluding the handling and transport costs.

However, the existing marketing system for coconuts comprises wider gaps between the producer and the consumer prices in a given time. This is unreasonably a higher margin resulting the primary producer to obtain a lower share of the consumer price, while the consumer to pay a higher price. Therefore, this study aims to evaluate the present coconut marketing system in Sri Lanka, focusing on three major coconut-producing districts, i.e. Kurunegala, Puttalam and Gampaha. The specific objectives of the study were to: i) identify the number of intermediaries involved in the collection and distribution channels of the domestic coconut marketing system for fresh coconut, copra and desiccated coconut processing industries, and ii) to estimate the collection, wholesaling and retailing margins of coconut marketing for the above three products.

Primary information/data relevant to the above specific objectives were collected from different marketing agents present in the coconut marketing channels. The total sample included 395 participants, i.e. growers (245), middle dealers (90), desiccated coconut producers (26), copra producers (34).

S R Samarajeewa, M T N Fernando, A M S K Abeysinghe and R Marasinghe

The financial grant (CARP/12/496/369) of the Sri Lanka Council for Agricultural Research Policy to conduct this study is greatly acknowledged

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, 14,488 coconut seedlings worth of Rs. 409,063.00 were issued. It was an increase of about 4,000 seedlings over 2002. The farm had a net profit of Rs. 193,614.23, which is about 178 times higher than the previous year (Table 30).

As in previous years, several field demonstration activities were also taken place at the farm.

Table 30 : *Annual income and expenditure of demonstration farm, Thabbowa*

Income			Expenditure	
Item	**Quantity Nuts/Seedlings**	**Value Rs.**	**Item**	**Value Rs.**
a. Sale of coconut	34171	239,991.49	a. Labour	317,134.33
b. Sale of coconut seedlings			b. Other materials	37,464.00
			c. Electricity	8,690.00
Poly bagged T x T	1663	99,780.00	d. Seed nuts	103,866.64
D x T	708	49,560.00		
R.D	25	1,500.00		
K.C	58	2,610.00		
Other	368	22,490.00		
Bare rooted T x T	10771	217,515.00		
D x T	895	15,608.00		
C. Sale of other crops		11,715.40		
Total Income		660,769.89		467,155.66
Profit: Rs. 193,614.23				

H A J Gunathilake and R A Swarnathilake

4.2 Animal breeding program

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

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
Ambakelle	Moora	19	14	20	10	26	10
PRS	Sri Lankan Boer	21	82	66	20	70	27

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REPORT OF THE GENETICS AND PLANT BREEDING DIVISION

Head – J. M. D. T. Everard MSc

1. SUMMARY

The highlight of the year, 2003 was the liberalization of coconut seed and seedling production policy to obtain private sector participation in implementing the national coconut-replanting program (NRP). Enrichment of the coconut germplasm by addition of ten exotic coconut varieties from the pacific (Papua New Guinea), discovery of seven new varieties of coconut from the Galle district, commencing work towards constructing a segregating population for mapping of the coconut genome and completing the preliminary work towards establishing a multi-locational trial to test the combining ability of dwarf brown with *tall* coconuts are the other noteworthy accomplishments during the year. The on going long term experiments on genetic evaluation of existing cultivars and germplasm crosses and maintenance of the gene banks were continued successfully during the same period.

Coconut Research Institute (CRI) and Coconut Cultivation Board (CCB) responded positively to the request of the Ministry of Plantation Industries to seek active participation of the private sector in coconut seed and seedling production for the NRP. A proposal was put forward at a national forum organized by the Ministry of Plantation Industries in Colombo on 10th November 2003 for exploring possibilities for private sector participation in seed and seedling production in the three main plantation crops, coconut, tea and rubber. CRI in addition to already existing privately owned plus palm estates, invited private sector to establish seed gardens and nurseries for seedling production with the involvement of CRI. Assistance of Department of Agriculture (DOA) was solicited for providing certification for seedlings. Seedling distribution was another potential area identified for private sector participation.

Enrichment of the coconut germplasm was accomplished by collecting 200-300 embryos of ten coconut germplasm accessions from Papua New Guinea. The accessions namely, Kar Kar Tall, Markem Valley Tall, Rennell Island Tall, Gezelle Peninsula Tall, Thalasia Tall, PNG Yellow Dwarf, Nias Yellow Dwarf, Malayan Red Dwarf, Malayan Yellow Dwarf and PNG Brown Dwarf are now being raised in Tissue Culture Laboratory of the CRI. Kar Kar Tall and Markem Valley Tall were collected from Kar Kar Island while the rest were collected from the Coconut Research Institute in Madang.

Unawatuna village was identified as a coconut bio-diversity hot spot in the country. Seven new coconut varieties were discovered from home gardens in an around Unawatuna village of the Galle district. These were clear phenotypic variants. In addition a wide variation in the normal tall coconut population was also observed. The local names of these variants are ran pol, juwan pol, dothalu pol, thatin pol, bothal thembili, and murusi pol and naw pol.

The novel approach, genome mapping for crop improvement was one of the newest projects identified by CRI for coconut improvement by marker assisted selection after establishing the Molecular Biology Laboratory in 2002. Establishing a segregating population of coconut as a prerequisite for mapping was commenced with the initiation of a pollination programme comprising 23 dwarf red coconut palms and a single tall palm to establish an F_1 mapping population of 200-300 individuals. Initially a framework map will be constructed and subsequently mapping of QTLs will commence after establishing a progeny evaluation trial for scoring economic traits.

The on going long term experiments on genetic evaluation of existing cultivars and germplasm crosses and maintenance of the gene banks continued successfully in all CRI and CCB estates and in private estates despite poor cooperation from some land owners.

Data collection of the experiment on evaluation of cultivars was limited to two locations, Bandirippuwa and Suriyapura. Data collection in evaluation of progenies was also limited to three locations, Bandirippuwa, Ratmalagara and Daisy Valley (Mawathagama).

The demand from the growers to establish CRISL98 (*tall x San Ramon*) was ever increasing despite the limited production. Still CRISL98 has to be produced by hand pollination. During the year 4272 seedlings have been issued for over 30 growers in five districts, Puttalam (2617), Kurunegala (1170), Gamapaha (350), Colombo (60) and Vavuniya (75). Establishment of Pallama Seed Garden (PSG) for mass production of CRISL98 was continued satisfactorily during the year. The total number of seedlings established to date were 9555. In order to widen the parent palm population to increase the production of San Ramon seedlings to accelerate the establishment of seed garden more palms were identified for self-pollination from a mixed block at PRS. This identification became possible because of the recent DNA assay criterion developed by the CRI.

Conservation of coconut germplasm was continued satisfactorily in all the field gene banks. The performance of germplasm accessions at Raddegoda Estate was remarkably good due to excellent cooperation from the estate officials. The seven new varieties identified from the Unawatuna village were now undergoing selfing for obtaining pure seeds for conservation.*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/ clayey	Wet

The experiment at the two sites, Bandirippuwa and Thammenna are comparable as they both commenced at the same year and similarly the trials at Palugaswewa and Suriyapura. However, collection of yield data at Thammenna and Palugaswewa sites were not continued since 2001 as the young palms became extremely weak due to poor maintenance.

The coconut yields (nuts/palm/year) of the five cultivars in these sites since 1994 are tabled below (Table 1). The significant feature of the data is the consistently better performance of dwarf x tall hybrids (dwarf green x tall and dwarf yellow x tall) in comparison to pure tall cultivars. In 2003 both dwarf green x tall and dwarf yellow x tall recorded a similar yield of 72 nuts/palm/year (= 14,400 nuts/ha/year) at Bandirippuwa. Tall x tall (CRIC60) followed with a yield of 44 nuts/palm/year (= 8,800 nuts/ha/year). Plus palm tall was slightly ahead of Moorock tall with a yield of 42 nuts/palm/year (= 8,400 nuts/ha/year). Moorock tall recorded the lowest with 40 nuts/palm/year (= 8,000 nuts/ha/year). The yields of the five cultivars in the Suriyapura estate were not so prominent during the year despite the marked better performance of Moorock tall above the other tall cultivars. This difference has been fairly consistent in the last five years in this particular site.

In the overall performance over the ten-year period the same pattern was observed with dwarf green x tall in the lead even ahead of dwarf yellow x tall and even more conspicuously ahead of pure tall cultivars. Performance of dwarf green x tall over the ten-year period was outstanding with an average of 72 nuts/palm/year (= 14,400 nuts/ha/year) at this Bandirippuwa site where the experiment was maintained with average management. *Dwarf yellow x tall* was also markedly better in the same site with the same level of management with an average yield of 65 nuts/palm/year (= 13,500 nuts/ha/year). There is hardly any difference seen among the three tall cultivars Tall x tall (CRIC60), Moorock tall and plus palm tall. The three recorded average yields of 47 42 and 46 nuts/palm/year (9,400, 8, 400 and 9,200 nuts/ha/year respectively. The pattern in the wet zone site was a little different favoring the Morrock tall cultivar which in fact was a selection from an estate in the wet zone. At this site despite dwarf green x tall and dwarf yellow x tall in the lead Morrock tall followed with a better performance than tall x tall and plus palm tall.

J.M.D.T. Everard, W.B.S. Fernando, M.H.L. Padmasiri and 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 51 *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 for planting one to two-acre small blocks. A steady demand for the new release CRISL98 (*tall x san Ramon*) was observed. During the year a total of 4,272 seedlings were issued for planting in five districts, Puttalam (2,617), Kurunegala (1,170), Gampaha (350), Colombo (600) and Vavuniya (75).

J.M.D.T. Everard, S. Mallawarachchi and S.A. Chandrasiri

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

The promising cross *dwarf green x san Ramon,* now under evaluation at the Daisy Valley estate Mawathagama was also decided to test under farmer conditions. Hand pollination of 100 *dwarf green* palms at ISG by San Ramon pollen was commenced for production of *dwarf green x San Ramon* seedlings. This is expected commence after the release of this variety in 1994.

J.M.D.T. Everard, S. Mallawarachchi and 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)

Four hundred and forty five individuals arising from 151 progeny families obtained by crossing palms selected for sustained high nut weights during adverse climatic conditions in 1991 were planted in field 14/ISG in 1993 in order to assess the progeny performance under low moisture and stress conditions. Another 95 progeny families arising from above crosses were established at the Maduru Oya Seed Garden in 1995. These families are maintained as observational trials until they reach the yield stabilizing age to commence analysis of fruit components and assessment of water-use-related physiological parameters.

L. Perera, J.M.D. T Everard, M H L Padmasiri and R Jayatillke

Table 1 : *Nut production (nuts /palm/year) of dwarf green x tall (CRIC65), dwarf yellow x tall (CRIC65), tall x tall (CRIC60), Moorock tall (MT) and plus palm tall (PPT) 1994 - 2003.*

Year/ years after planting		'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	Mean
		10	11	12	13	14	15	16	17	18	19	
Site - Bandirippuwa	**Cultivar**											
Nuts/ Palm/ Year	DGxT	101	70	67	46	47	103	78	89	43	72	72
	DyxT	83	61	65	45	57	88	71	76	35	72	65
	TxT	51	47	48	32	32	63	64	64	29	44	47
	MT	39	45	42	32	30	51	55	52	29	40	42
	PPT	50	50	44	34	34	56	60	59	32	42	46
Site - Thammenna												
Nuts/ Palm/ Year	DGxT	60	80	73	81	32	107	30	89	-	-	69
	DyxT	39	63	65	71	32	81	35	72	-	-	57
	TxT	28	46	51	46	20	45	26	49	-	-	39
	MT	24	35	36	36	17	39	25	41	-	-	32
	PPT	31	47	49	49	22	46	30	49	-	-	40
Site - Palugaswewa												
Nuts/ Palm/ Year	DGxT	-	-	45	63	34	52	55	61	-	-	52
	DyxT	-	-	34	61	36	51	63	59	-	-	51
	TxT	-	-	32	63	20	42	46	38	-	-	40
	MT	-	-	18	59	18	41	44	41	-	-	37
	PPT	-	-	24	53	17	46	50	46	-	-	40
Site - Suriyapura												
Nuts/ Palm/ Year	DGxT	-	-	26	25	36	61	61	64	46	64	48
	DyxT	-	-	17	22	35	51	52	55	39	59	41
	TxT	-	-	10	16	27	29	36	42	27	39	28
	MT	-	-	11	10	30	37	41	50	30	51	32
	PPT	-	-	12	17	20	29	38	40	26	42	28

J.M.D.T. Everard, W.B.S. Fernando, M.H.L. Padmasiri and S. Mallawarachchi

Experiment 12.2.2 : Progeny trial for testing putative drought tolerant palms by the performance of their progeny at ISG (1988)

Design : Fully randomized with minimum of 4 progenies each from 56 families

Location : Isolated Seed Garden Ambakelle

Agro-climatic zone/soil type : Dry intermediate zone;

This experiment was terminated as the performance of palms has been far below than expected. Early set back to seedlings due to water logging and high planting density could have been the probable reasons. It was decided to divest this field into a mix field of tall and dwarf green in order increase the production of dwarf green x tall hybrids.

J.M.D.T. Everard and M H L Padmasiri

Experiment 11.2/12.3 : Crossing of selected palms at ISG with promising germplasm accessions (1993)

Design : *Five Randomized blocks with a replicate of each cross. Plot size = 12*

Experiment Number	Location	Year of establishment	Soil type	Agro-ecological region
11.3a	Girtland	1995	Gravel	Wet intermediate
11.2a	Melsiripura	1995	Reddish brown latasol	Wet intermediate
11.2b	Siringapatha	1995	Sandy Loam	Wet zone
12.3b	Bataatta	1996	Reddish brown earth	Dry zone
12.3c	Kivulakelle	1997	Red yellow latasol	Dry zone

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.

The measurement of growth was completed in all the locations and the early growth failed to reveal significant differences among crosses for any of the growth parameters measured including physiological and biochemical indicators of vigour and drought tolerance. Flowering has initiated in all the sites.

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

Experiment 12.7.3 : Evaluation of Dwarf green x Debarayaya tall (Raddegoda)

Forty-eight seedlings of *dwarf green x Debarayaya tall* were planted with an equal number of *dwarf green x tall* (CRIC65) seedlings for comparison at Raddegoda estate Delwita in 1995. All seedlings are now in flower and bearing. Yield data of these palms will collected from year 2004 onwards.

J.M.D.T. Everard and 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 were established at Loling Estate Halkandawila, Payagala in May 1997 in order to evaluate the progenies for sap production. The growth characters measured after three and half years from planting are summarized in Table 2. As an extension to this trial, 25 Navasi, 14 Kamandala, 25 Andigama Tall, 39 St. Anne's tall and 33 Tall x Debarayaya along with 77 Tall x Tall (guard rows) seedlings were also planted.

Table 2 : *Status of palms at the Loling estate, Payagala*

Cross	*Total planted*	*Bearing*	*Young palms*	*Vacancies*
Dwarf green x Ambakelle tall	165	104	53	8
Ambakelle special	52	6	43	3
Cameroon Red Dwarf x Ambakelle tall	120	62	47	11
Dwarf green x Debarayaya tall	117	77	34	6

J.M.D.T. Everard and 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.

Design : Factorial with 3 varieties and 3 fertilizer levels in a randomized block design with 3 replicates per treatment.

No. of palms/plot: 10 palms

Crosses	**Fertilizer levels**
Tall x Dwarf green (V1)	Recommended APM dosage (T1)
Tall x Tall (V2)	Half the recommended dosage (T2)
Tall x San Ramon (V3)	One and half the recommended dosage (T3)

Treatments

V1T1 V1T2 V1T3
V2T1 V2T2 V2T3
V3T1 V3T2 V3T3

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

Differential fertilizer application was commenced after 75% of the palms attained flowering at Ratmalagara and Bandirippuwa sites. Since the CRI has changed its fertilizer recommendations form APM to site specific recommendations the fertilizer treatment was stopped and all palms were treated according to differential fertilizer recommendation based on the leaf analysis. The nut yield during the period from 1998-2003 at the two sites are given in Tables 3 and Table 4.

All the three varieties in both sites have shown a recovery from the effect of drought observed in 2002. Recovery of tall x dwarf green has been quite outstanding at Ratmalagara recording a yield of 20,400 nuts/ha in the year comparing to 9,000 nuts/ha in the previous year. Similar two-fold increase in *tall x dwarf green* was also evident at Bandiripuuwa. Tall x tall also almost doubled its yield at Ratmalagara.

Table 3 : *Nut yield (nuts/palm/yr.) of the progenies, tall x dwarf green, tall x tall and tall x san Ramon during 1998-2003*

Site	Bandirippuwa[1]						
Year	1998	1999	2000	2001	2002	2003	Six-year average
Years after planting	13	14	15	16	17	18	
Variety							
T x DG	41	97	74	78	30	64	64 (or 12,800 nuts/ha/yr)
T x T	40	54	61	51	25	39	45 (or 9,000 nuts/ha/yr)
T x SR	34	40	54	48	25	37	40 (or 8,000 nuts/ha/yr)

Table 4 : *Nut yield (nuts/palm/yr.) of the progenies, tall x dwarf green, tall x tall and tall x san Ramon during 1998-2003.*

Site	Ratmalagara						
Year	1998	1999	2000	2001	2002	2003	Six-year average
Years after planting	13	14	15	16	17	18	
Variety							
T x DG	50	110	89	100	45	102	83 (or 16,600 nuts/ha/yr)
T x T	30	60	66	72	31	66	54 (or 10,800 nuts/ha/yr)
T x SR	33	57	68	68	34	53	52 (10,400 nuts/ha/yr)

In spite of fluctuations in yield, all the three progeny during the last six-year period has given yields above 8,000 nuts/ha/year at both sites. Among the three *tall x dwarf green* has been exceptional with an average yield of 16,600 nuts/ha/year at the Ratmalagara site. The yields of *tall x tall* and *tall x San Ramon* at this site were 10.800 and 10,400 nuts/ha/year respectively. Corresponding yields of *tall x dwarf green*, *tall x tall* and *tall x San Ramon* at the Bandirippuwa site were 16,600, 10,800 and 10,400 respectively.

The fruit components, fresh nut weight, husked nut weight, split nut weight and kernel weight and estimated copra weight (copra weight = 0.32 x husked nut weight) of the three progenies over the last six years (1998-2002) is given Table 5. The drought has adversely affected all components of the fruit in the previous year. Remarkable recovery was seen in all the components of fruit during the year. Six-year averages at both sites clearly indicate *tall x san Ramon* (286g of copra/nut) as the largest producer of copra comparing to *tall x tall* (254g of copra/nut) and *tall x dwarf green* (224 g of copra/nut).

The overall copra out turn among the three progenies was significantly higher in *Tall x dwarf green* in spite of the low copra out turn per nut. The six-year average copra productivity of *tall x dwarf green* at Ratmalagara, 3.7 Mt of copra/ha/year under rain-fed conditions is a substantial outturn of copra under all standards. *Tall x san Ramon* ranked second with 2.98 Mt of copra/ha/year. *Tall x tall* recorded with 2.75 Mt of copra/ha/year.

Table 5 : *Fruit components of the crosses tall x dwarf green, tall x tall and tall x San Ramon at Ratmalagara Estate from 1998-2003*

Site:	Ratmalagara					
	1998	1999	2000	2001	2002	2003
Progeny: Tall x Dwarf Green						
Fresh weight	1457	1223	1373	1362	1489	1397
Husked nut weight	660	655	742	692	764	689
Split nut weight	489	502	544	531	567	512
Kernel weight	325	325	371	353	350	309
Estimated copra weight	211	210	237	221	244	220

Site:	Ratmalagara					
Progeny: Tall x Tall						
Fresh weight	**1397**	**1541**	**1587**	**1621**	**1476**	1536
Husked nut weight	749	810	870	841	697	792
Split nut weight	555	613	645	623	528	599
Kernel weight	351	380	419	407	318	366
Estimated copra weight	**240**	**259**	**278**	**269**	**223**	**253**
Progeny: Tall x San Ramon						
Fresh weight	**1718**	**1873**	**1942**	**1913**	**1531**	1867
Husked nut weight	892	943	996	889	747	888
Split nut weight	646	690	838	660	543	636
Kernel weight	421	439	472	434	329	395
Estimated copra weight	**285**	**302**	**319**	**284**	**239**	**284**

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The progeny trials at the two sites, Mangala Eliya and Andigama are unsatisfactory due to poor management and hence data were not analyzed. The trial at Daisy Valley however, is progressing well and yields of the five crosses tested are given in table 6.

Table 6 : *Nut yield (number of nuts/palm/yr.) of the progeny trial at Daisy Valley Estates (1987)*

Year	2000	2001	2002	2003	Four-year Average
Years after planting	13	14	15	16	
Cultivar					
Tall x dwarf green	82	60	57	47	62
Tall x Tall	46	38	36	33	38
Tall x San Ramon	48	41	31	34	39
Dwarf green x San Ramon	78	57	53	46	59
Dwarf green x Tall	88	62	56	50	64

Interesting feature of the experiment is the evaluation of the performance of *dwarf green x San Ramon* against *dwarf green x Sri Lanka Tall.* At the end of the sixteenth year yields of the two inter varietal hybrids reached almost the same while tall cultivars, *Sri Lanka Tall x Sri Lanka Tall* and *Sri Lanka Tall x San Ramon* significantly less performed. Tall in all the progenies except of the cross, *tall* x san Ramon where a drastic drop was recorded than the previous year. Yields of all the five cultivars are far below expected for this age and this is due to the ill drained conditions in about of 50% of the land area of this experimental site.

The fruit components were analyzed for two consecutive years in these progenies and the results clearly emphasized the prominence of the cross *Dwarf green x san Ramon* in terms of total copra outturn with an overall average of 2.83 Mt/ha (Table 7). The other *dwarf x tall hybrids, Sri Lanka tall x dwarf green* and its reciprocal recorded significantly higher copra yields comparing to pure tall crosses, *Sri Tall x Sri Lanka Tall* and *Sri Lanka Tall x San Ramon.* The inter-geographical tall hybrid, *Sri Lanka Tall x San Ramon* performed better than the pure *Sri Lanka Tall* intra varietal cross.

Table 7 : *Fruit components of progenies evaluated at Daisy Estates (1987)*

Progeny	Year	Fresh nut weight	Husk nut weight	Split nut weight	Kernel weight	Estim-ated copra weight kg/nut	Copra prod-uction Kg/ palm/yr	Copra prod-uction Mt/ ha/yr
Tall x dwarf green	2002	1791	783	573	356	251	14.30	2.86
	2003	1575	761	568	375	230	10.81	2.16
	Mean	**1683**	**772**	**570.5**	**365**	**240**	**12.50**	**2.50**
Tall x Tall	2002	1816	832	603	366	266	9.57	1.91
	2003	1713	828	624	380	252	8.31	1.66
	Mean	**1764.5**	**830**	**613.5**	**373**	**259**	**8.93**	**1.78**
Tall x San Ramon	2002	2299	1012	720	441	324	10.04	2.00
	2003	2115	1006	735	483	304	10.33	2.06
	Mean	**2207**	**1009**	**727.5**	**462**	**314**	**10.20**	**2.04**
Dwarf green x San Ramon	2002	1884	931	632	374	298	15.79	3.15
	2003	1752	937	638	377	275	12.65	2.53
	Mean	**1818**	**934**	**635**	**375**	**286**	**14.18**	**2.83**
Dwarf green x Tall	2002	1685	762	551	345	244	13.66	2.73
	2003	1493	713	547	347	216	10.80	2.16
	Mean	**1589**	**737.5**	**549**	**346**	**230**	**12.19**	**2.43**

Two observation trials established at Sirikandura (1989) with *tall x dwarf green, tall x dwarf yellow, tall x san Ramon* and *tall x tall* at Ratmalagara (1989) with *dwarf green x tall, dwarf yellow x tall, dwarf green x san Ramon and dwarf yellow x san Ramon* were monitored during the year.

J.M.D.T. Everard, N. Hearth, W.B.S. Fernando and K. Ekanayake

Experiment 12.6 : Comparative evaluation of DG x Tall hybrid progeny of parents of the first and second generation palms at the ISG for yield and physiological drought tolerance at Andigama Farm Giriulla (1993).

Design : Complete Randomized Block design with 8 blocks; 8 palms/plot each plot surrounded by a guard row of Ambakelle special.

Crosses : DG x Tall from first generation dwarf selected at ISG
DG x Tall from second generation dwarf at ISG
DG x T (CRIC65)Ambakelle special

Year of Planting: December 1993

This trial despite early set back due to water logging and severe rat damage due to poor management have recovered to a great extent and is now progressing well. Collection of yield data was not commenced as it is still too early for the yields to stabilize in these progenies.

J.M.D.T. Everard and R. Jayathilaka

NEW PROJECT I : GENETIC ANALYSIS OF KING COCONUT

Genetic analysis of existing ecotypes and breeding of an improved strain of King Coconut for beverage purposes is a timely need because of the present trend worldwide for natural drinks. King coconut commonly known as Thembili belongs to the semi-tall variety *aurantiaca* within the species *Cocos nucifera.* It has a relatively high sucrose content in its nut water providing a refreshing drink. A comparison of characters relevant to the industrial use of coconut kernel of the three main varieties grown in Sri Lanka indicates that *aurantiaca* is low in oil and also having a thin kernel.

King coconut palms have a frail appearance, with less trunk girth, short leaflets, lean leaf stalks and sparsely arranged leaves on the crown, which is notably different from other ordinary coconuts. Nevertheless, the rate of photosynthesis of King Coconut is high despite the lesser chlorophyll content. Nitrate reductase activity, which has a highly significant and positive correlation with the annual nut yield is also higher in king coconut than other varieties of coconut. King coconut usually produces approximately 18 bunches per palm per year.

A research programme was initiated in 1999 to identify King Coconut ecotypes with desirable characters for introgressing into an improved strain. In this study, a reasonably large populations of King Coconut were identified and desirable characters were identified. A total of 45 palms from 4 populations (Marandawila Estate, Walahapitiya Estate, Walpita Farm and Bandirippuwa Estate) were identified as promising and an assisted self-pollination was carried out to raise progenies from selected mother palms. These progenies are now being evaluated, to see whether the transmission of characters is efficient or not. These well designed field experiment at Raddegoda Estate, Ridigama and also at Pallama Seed Garden. The next stage would be to initiate a programme of hybridization for possible recombination of characters after a proper evaluation in future.

A large variability exists among King coconut palms in the sweetness of nut water despite being picked at the correct stage of maturity (7-8 months after pollination) indicating considerable genetic diversity. It is imperative to analyze this diversity using molecular marker techniques before starting a hybridization programme to recombine the characters of above ecotypes. In addition to that, it is useful to identify new King coconut populations which consist peculiar characters such as, sweet nut water, different nut characters (colour, shape, size and etc.) and bearing characters (regular bearing and higher number of nuts), all over the country. After that, the proper variability should be analyzed using modern molecular marker technologies to recognize novel genotypes. Therefore the immediate step would be a molecular marker analysis to study the genetic diversity between and within selected king coconut ecotypes and also novel populations.

Action Plan

ACTIVITY	2004											
	J	F	M	A	M	J	J	A	S	O	N	D
Record flowering of already established trials at Raddegoda and Pallama			*			*			*			*
Identify new King coconut populations islandwide				*	*	*						
Collection of leaf samples from 20 palms from each ecotype in trials and DNA extraction				*								
DNA extraction from novel populations						*						
Molecular assaying					*	*	*	*				
Report genetic diversity among King coconut in Sri Lanka												*

C.K. Bandaranayake

NEW PROJECT II : 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

The variety *nana* or the dwarf coconuts in Sri Lanka included three colour forms, the red, yellow and green. However, dwarf brown colored form though reported in the Coconut Genetic Resources database, the number of geographical variants of this form is very restricted. Under the coconut germplasm collection and conservation programme of the CRISL, initiated in 1986 a few dwarf looking coconut palms with brown colour nuts, petioles and inflorescence were identified, mainly as single palms in home gardens. The short height (4m), narrow stem, absence of bole, short and narrow fronds and leaflets, large number of small nuts per bunch (50-80 in average), presence of large number of female flowers (average of 64 ranged between 15 to 208 in a inflorescence) and overlapping male and female phase, confirmed this collection of palms as another form of dwarf coconuts. DNA analysis based on Amplified Fragment Length Polymorphism (AFLP) further confirmed the dwarf identity of these palms and hence was named as Sri Lanka brown dwarf. Palms rose from open pollinated nuts and self-pollinated nuts of these dwarf brown palms planted in 1993 at the Pottukulama Research Station flowered in three years and showed a better vigour than other dwarf coconuts.

Several natural hybrids (dwarf brown crossed with pollen from unknown tall parents) were also found in this genetic conservation block and they took nearly three and half years to flower and produced nuts with an average husked nut weight of 880g. Kernel weighed about 386g. Average nut yield was around 75nuts per palm per year. It was observed also noted that the bunch stalk of these natural hybrids were stronger than other recommended hybrids, *dwarf green x tall* and *dwarf yellow x tall* and hence immature nut fall during early stage of bearing and drought conditions was less. The natural hybrids also showed a high degree of resistance to red weevil and a reasonable level of tolerance to prolong drought conditions in the particular conservation block. Therefore, dwarf brown x Ambakelle tall and its reciprocal and dwarf brown x San Ramon were thought worthwhile for testing in agro-ecological zones proposed for testing as prospective future hybrids taking dwarf green x San Ramon and dwarf green x tall (CRIC65) as controls.

During the year a pollination programme was initiated to raise seed nuts of *dwarf brown x tall* and *dwarf brown x San Ramon* using 14 pure *dwarf brown* palms identified as female parents at the Pottukulama Research Station and pollen from Ambakelle and from Bandirippuwa respectively for tall and San Ramon. Pollination programme to produce these hybrids were carried out at the Isolated Seed Garden using 30 palms each of selected Ambakelle tall and *dwarf green* palms and Pottukulama Research Station last year. Nuts of dwarf green x San Ramon was proposed to obtain from the on going pollination programme at Isolated Seed garden for the production of this variety. Collection of hand-pollinated nuts was commenced in May 2003 and following number of seed nuts have already been harvested and laid in the nursery.

Tall x dwarf brown	891
Dwarf brown x tall	167
Dwarf brown x san Ramon	57
Dwarf green x tall	221

This trial was proposed to replicate in five different location representing different agro-climatic regions as well as different major coconut growing soil series. During the year three prospective sites, Ratmalagara estate in Madampe, Walpita estate, Walpita, and Beligama farm in Galawela were identified. Ratmalagara and Walpita estates were selected to

represent class three and four soils of Andigama/Wilathhawa soils series in intermediate dry zone and class two soils of Pallama series in Wet zone respectively. Beligama farm was selected to represent class two soils of Melsiripura series in the intermediate dry zone.

L. Perera and R. Jayathilaka

NEW PROJECT III : COCONUT GENOME MAPPING

Developing a high-density linkage map of the 16 pairs of chromosomes would be very useful for coconut because of its disadvantages at conventional breeding such as long juvenile period, inherent heterozygosity, out breeding nature, lack of a viable mechanism for vegetative propagation, and time, land and other cost constraints. Modern molecular technologies have a great potential to accelerate breeding programmes by identification of genetically diverse populations for harnessing maximum heterosis and tagging important QTLs for marker assisted breeding.

Linkage maps composed of DNA markers are now available for many crops. But construction of such a map for coconut is not an easy due to non-availability of clearly characterized mapping populations and limited availability of informative molecular markers. Therefore, the first step in genome mapping is to construct a segregating family/families of a reasonable size. The major constraint for producing a fairly large mapping population in coconut is the limited number of seeds produced from a particular mother palm and also the low rate of success in artificial pollination.

Combining several separate families to produce a single mapping population could be taken as an alternative for increasing family size. However, this often leads to human errors when simultaneous handling of different types of pollen is required for a longer period. An alternative is to use a single pollen parent. Dwarf coconuts are highly homozygous and therefore, possibly share identical genotypes for a great majority of genetic loci. In view of this understanding, it is appropriate to choose several dwarf palms from a population as female parents and a single male tall coconut as pollen donor to construct the mapping population.

A total of 33 dwarf red palms from the germplasm conservation block at 50-acre block, Bandirippuwa Estate were selected to fulfill the need of the mother parent. A single tall palm was chosen also from Evaluation of Cultivars experiment at Bandirippuwa Estate as the male parent. The hand pollination programme was initiated to produce a family of *dwarf red x tall* of 500 individuals. DNA extraction from parents and progeny and molecular marker analysis will be started as the family begins to develop with already available coconut micro-satellite markers. The framework map for coconut is expected to develop in 2006. Meanwhile, important agronomic characters will be measured of individual members of the family from the very outset of emergence from seeds.

C.K. Banadaranayake

PROJECT : COLLECTION CONSERVATION AND EVALUATION OF COCONUT GERMPLASM

Enrichment of coconut germplasm

Four promising Indian coconut varieties, West Coast Tall, Laccadive Ordinary Tall, Andaman Tall and Banawali Round Dwarf brought to the country as *in-vitro* cultured embryos are being raised in the Tissue Culture Laboratory. More germplasm accessions were brought to the country from Papua New Guinea.

More recently carried out DNA based germplasm characterization studies at the Coconut Research Institute, revealed that the genetic base of the available coconut gene pool in Sri Lanka is narrow and hence breeding materials for further improvement of coconut is limited within the country. Therefore, efforts made to import coconut germplasm from Southeast Asia and the Pacific became a reality in the year 2003. During the year CRISL was able to negotiate with PNG to import ten coconut varieties from PNG in exchange of five Sri Lanka coconut varieties, Ambakelle tall, San Ramon tall, dwarf green, Dikiri and Gon thembili.

Senior Plant Breeder from the CRISL, Dr. L. Perera visited PNG during the year to identify suitable varieties for importation giving due regard to morphological diversity and phyto-sanitary safety. The collections were made from the National Coconut Gene Bank of PNG, Cocoa and Coconut Research Institute in Madang Province and from two sites Kar Kar Island and Markham Valley farm in Morobe Province.

Varieties of Coconut imported Papua New Guinea

Name of the variety	No. of embryos collected	Name of the variety	No. of embryos collected
Kar Kar Tall	300	PNG Yellow Dwarf	200
Markham Valley Tall	300	Nias Yellow dwarf	200
Rennell Island Tall	200	Malayan Red Dwarf	200
Gezelle Peninsula Tall	200	Malayan Yellow Dwarf	200
Thalasia Semi Tall	200	PNG Brown Dwarf	200

The palm numbers from which nuts were collected for embryo excision are given below for all varieties

Kar Kar Tall (KKT)

KKT 1 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
1.01	21	2.02	19	1.03	21
2.05	29	2.07	3	4.05	20
4.06	11				

KKT block 3 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
27.07	11	28.12	24	28.13	16
28.16	16	29.14	19	29.10	04
28.04	19				

KKT block 2 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
-	09	-	13	-	05

Markham Valley Tall (MVT)

MVT block 1, gene bank

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
6.02	01	5.02	06	5.03	15
6.04	13	6.05	10	5.06	10
6.06	30	5.07	24	5.09	10
6.10	12	7.-	05	8.09	04

MVT block, gene bank

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
4.02	14	5.03	11	5.07	12

MVT block 3 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
61.16	15	60.17	13	60.18	10
61.18	16	60.21	17	61.22	7
61.23	7	60.23	10	60.25	7
61.26	12				

Rennel Tall (RIT)

RIT block 1 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
49.01	14	50.01	15	50.02	13
49.02	8	50.04	34	49.04	09
50.07	7	50.13	6	49.13	05

RIT block 2 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
29.28	30	29.27	22	28.27	38
29.26	12	29.17	17	28.16	14

Thalasia Red Semi Tall (TRD)

TRD block 1 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
1.1	46	2.1	24	2.2	27
2.3	28	3.4	50	3.5	25
3.6	50	2.9	34		

Gezelle Peninsular Tall (GLT)

GLT block 4 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
39.01	22	40.03	33	40.04	26
41.05	24	41.06	33	41.07	26
41.08	30				

GLT block 2 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
46.01	27	46.02	20	46.05	23

PNG Brown Dwarf (PBD)

PBD block 1 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
23.01	04	22.01	01	21.05	08
20.04	35	22.05	04	21.04	16
21.06	27	20.05	18	22.07	27
22.08	10	21.08	7	22.09	8
21.10	19	22.10	27	21.11	16
23.11	13	20.10	10	23.10	13
20.11	7	20.09	10	20.08	8

PNG Yellow Dwarf (PYD)

PYD block 1 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
1.02	83	2.05	15	3.07	42
2.07	29	2.08	18	2.09	08
1.09	19	1.08	09	1.06	30
1.04	57				

Nias Yellow Dwarf (NYD)

NYD block 1 in Gene bank, Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
39.01	20	39.02	21	39.03	15
39.05	14	39.04	28	39.05	04
39.06	25	39.07	43	39.08	22
39.09	25	39.10	13	40.09	38
40.11	48				

Malayan Red Dwarf (MRD)

MRD Plantation in Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
122	12	121	27	120	17
119	20	118	29	117	24
143	19	144	23	145	21
146	14	147	38	148	38

Malayan Yellow Dwarf (MYD)

MYD Plantation in Madang

Palm No.	No. of nuts collected	Palm No.	No. of nuts collected	Palm No.	No. of nuts collected
71	23	70	41	94	11
95	28	122	18	146	36
145	31	144	22	118	36
143	25				

Some special characters of the imported germplasm

Name of the variety	Remarks
Kar Kar Tall	Round big nuts with on average 535g of endosperm per nut
Markham Valley Tall	Large nuts of about 3370g in average fruit weight. Adapted to dry climate
Rennel Island Tall	Round big nuts. Proven combiner for many famous coconut hybrids
Gezelle Peninsula Tall	Medium size nuts with about 400g endosperm per nut
Thalasia Semi Tall	A semi tall type with medium nuts. Orange colour nuts.
PNG Yellow Dwarf	Very small fruits with very large number of fruits per bunch
Nias Yellow dwarf	Proven combiner for many hybrids
Malayan Red Dwarf	Proven combiner for many hybrids
Malayan Yellow Dwarf	Proven combiner for many hybrids
PNG Brown Dwarf	Proven combiner for many PNG hybrids

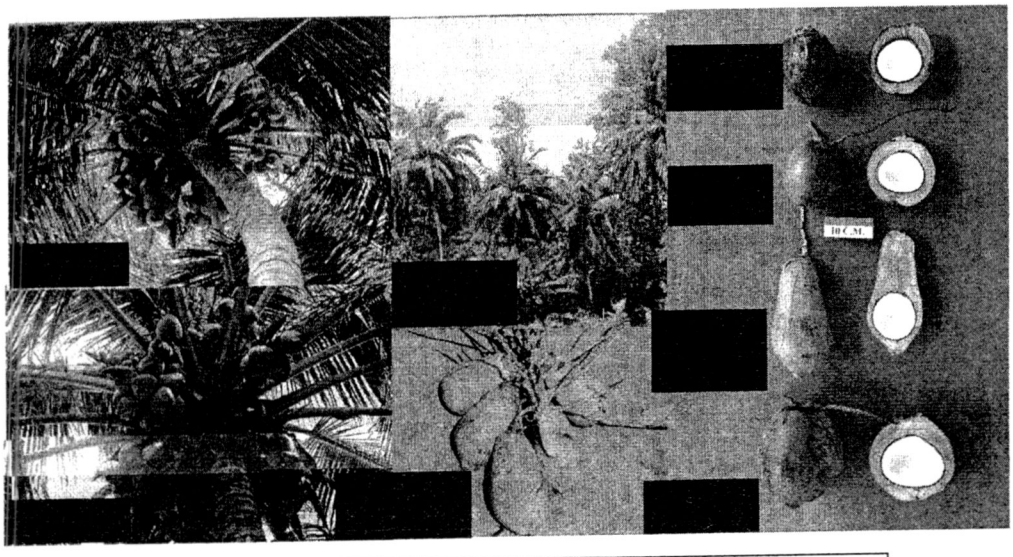
These embryos are being cultured *in-vitro* at the Tissue Culture Division. The status of the embryo germination of these varieties and embryos imported from India last year will be compiled in the section on Annual Report of the Tissue Culture Division.

L. Perera

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

Conservation of coconut germplasm was continued with proper maintenance of all field gene banks and collection of characterization data. The COGENT's data base (CGRD) was updated with information gathered from all conserved accessions.

Following a survey carried out to identify farmer's varieties of coconut in three communities of the country, Dodanduwa (Galle), Wilpotha (Chilaw) and Thuththiripitigama (Hettipola) selected for the COGENT Project on Poverty Allieviation, Unawatuna became evident as a as a coconut bio-diversity hot spot in the country.



Coconut phenotypes identified from the Unawatuna

Several expeditions were made in search of coconut phenotypic variants by carrying out informal surveys such as collecting information from climbers and formal and informal village leaders in an around Unawatuna village of the Galle district. There were seven clear variants in addition to a wide variety of normal tall coconut palms observed. The local names of these variants are ran pol, juwan pol, dothalu pol, thatin pol, bothal thembili, murusi pol and naw pol. These varieties will be studied in more detail to identify there morphological and molecular differences.

The field gene banks at Bandirippuwa, Pottukulama, Lenawa, Pallama Seed Garden and Kohombana at Coconut Cultivation Board (CCB) premises, Gonagolla, Amparai 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. The trials established for evaluation of germplasm and crosses generated from germplasm accessions were maintained successfully.

J.M.D.T. Everard and G. K. Ekanayake

Experiment 12.7.2 : Status of field gene banks (1988 onwards)

Yield recording was continued at the gene bank at PRS conservation block in 10 accessions. Mean annual nut yields of the accessions are given in Table 8.

Table 8 : *Yield data of seven germplasm* accessions at the Pottukulama Gene bank (sample size = 30 palms)

Accession	*Age (Yr.)*	*Nuts/palm/year*			
Year		**2000**	**2001**	**2002**	**2003**
Moorock	13	42	32	36	42
Palugaswewa	13	55	46	36	63
Pitiyakande	13	60	42	44	59
Clovis	12	43	40	22	40
Margaret	12	63	58	36	54
Namalwatta	9	63	56	38	62
St. Anne's	9	59	43	44	60

The status of field gene banks and various other conservation blocks as at 31st December 2002 are summarized in preceding tables (Tables 9 - Table 17).

Table 9 : *The status of the Pottukulma Field Gene Bank as at 31st December 2003(Planted in 1988/89).*

Accession	Number of bearing	Number of young palms	Number of vacancies	Total planted
1. Moorock	81	0	1	82
2. Palugaswewa	79	0	6	85
3. Pitiyakande	77	0	8	85
4. Clovis	75	0	10	85
5. Namalwatta	81	0	5	85
6. St. Anne's	79	0	6	85
7. Margaret	78	0	7	85
8. Kasagala	69	0	11	80
9. Deberayaya	79	0	2	81
10. Kundasale Dwarf	39	15	34	88
11. Akuressa	78	0	12	90
12. Ambakelle special	81	0	10	91
13. Melsiripura	78	0	13	91
14. Mangala Eliya	79	0	7	86
15. Goyambokka	81	0	9	90
16. Cameroon Red Dwarf	45	0	41	86
17. Goluwapokuna	74	0	7	81
18. Keenakelle	65	0	25	90
19. Dwarf Brown	27	0	74	102
20. Maliboda	78	0	11	90
21. Horakelle	65	0	25	90
22. Walahapitiya	66	9	8	85
23. Wellawa	51	1	20	79
24. Embryo Culture Plants	16	0	3	19
25. Brazillian Green Dwarf	16	0	23	39

J.M.D.T. Everard, N. Herath

Table 10 : *The status of the Kotakanada (Bandirppuwa) Filed Gene Bank as at 31st December 2003 (Planted in 1988/89).*

Accession	Number of bearing	Number of young palms	Number of vacancies	Total planted
1. Wellawa	80	0	4	84
2. Pitiyakande	80	0	6	86
3. Ambakelle Tall	72	0	14	86
4. Moorock	36	6	48	84
5. Namalwatta	19	0	65	84
6. Debarayaya	56	0	24	80
7. Clovis	77	0	8	85
8. Palugaswewa	68	0	12	80
9. Ambakelle Special	76	0	2	78
10. Akuressa	73	0	13	86

J.M.D.T. Everard, N. Herath

Table 11. : *The status of the Pallama Field Gene Bank as at 31st December 2003(Planted from 1999-2002)*

Accession	Number of bearing	Number of young palms	Number of vacancies	Total planted
1. Thelidiriya (TLD)	None	47	6	53
2. Kalawewa (KL)	None	60	0	60
3. Ambakelle Special (AS)	None	60	0	60
4. Galadivulwewa (GDW)	None	57	3	60
5. Sindurupitiya (SP)	None	25	3	28
6. Wanathawillu (NM)	None	55	5	60
7. Ihala Kagama (IK)	None	60	0	60
8. Vijithapura (VJ)	None	61	0	61
9. Mahawelathenna (MWT)	None	46	8	54
10. Hangiliyagama (HNG)	None	60	0	60
11. Blackstone (BT)	None	52	5	57
12. Lanlib (LL)	None	58	2	60
13. Kirillapone	None	45	5	50
14. Gannoruwa	None	41	6	47
15. Kalagedihena	None	60	0	60
16. Yakkala	None	57	3	60
17. Bogamuwa	None	51	9	60
18. Rambukkana	None	50	10	60
19. Nittambuwa	None	5	5	60
20. Amparai	None	56	16	72
21. Damana	None	30	20	50
22. Deegawapi	None	43	4	47
23. Batheegama	None	56	4	60
24. Aparekka	None	59	1	60
25. Diddenipotha	None	57	3	60

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Table 12 : *The status of the Lenawa Field Gene Bank as at 31st December 2003(Planted in 1998)*

Accession	Number of flowering palms	Number of young palms	Number of vacancies	Total planted
1. Sitrakala (SK)	51	26	2	79
2. Wilhelmina (WHM)	33	41	4	78
3. Kivulakelle (KK)	40	37	3	80
4. Thammenna ™	51	17	2	70
5. Yatawatta (YT)	49	15	6	70
6. Marandawila (MW)	46	29	5	80
7. Mirishena (MH)	50	6	4	60
8. *Tall x tall*	25	53	2	80
9. Andigama (AND)	29	47	4	80
10. Dehigahalanda (DHL)	6	29	14	49
11. Dickwella (DW)	11	37	2	50
12. Haragama (HG)	7	52	6	65
13. Namalwatta (NM)	11	62	2	75
14. Deberayaya (DB)	14	48	13	75
15. Goyambokka (GB)	24	41	10	75
16. BLW	-	6	16	22
17. (Tissue Cultured)		7	15	22
187. Beliatta		6	16	22

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Table 13 : *The status of the Raddegoda Field Gene Bank as at 31st December 2001(Planted in 1996)*

Accession	Number of flowering palms	Number of young palms	Number of vacancies	Total planted
1. Daddalla	1	41	7	48
2. Galenbindunuwewa	4	53	5	58
3. Madagama	4	43	22	65
4. Millawana	3	37	28	65
5. Mahakumbukadawala	11	47	18	65
6. Beliatta	3	12	53	65
7. Wellawaya (G)	1	4	51	55
8. Raddegoda	5	15	34	50
9. Wellawaya (B)	8	39	5	44
10. Wakwella	1	38	7	45
11. Aluthwatta	4	28	22	50
12. Zoysawatta	0	58	18	76
13. Pamunugama	4	47	9	56
14. Sedawatta	2	53	24	77
15. Iranawilla	9	55	2	57
16. Adikarigoda	5	74	1	75
17. Yodakandiya	4	97	6	103
18 Magama	8	68	3	71

J.M.D.T. Everard and R.B. Attanayake

Table 14 : *The status of the Kohobana Field Gene Bank as at 31st December 2001(Planted in 1999/2000)*

Accession	Number of flowering palms	Number of young palms	Number of vacancies	Total planted
Magama	NA	NA	NA	146
Wellawaya	NA	NA	NA	57
Beliatta	NA	NA	NA	62
Kivulakelle	NA	NA	NA	165
Clovis	NA	NA	NA	126
Debarayaya	NA	NA	NA	160
Dickwella	NA	NA	NA	95
T x T (HP)	NA	NA	NA	203
Ambakelle special	NA	NA	NA	137
Kirinda	NA	NA	NA	146

NA = Not available

J.M.D.T. Everard

Table 15 : *The status of the crop museum at Bandirippuwa as at 31st December 2002 (Planted in 1983)*

Accession	Number of bearing palms	Number of young palms	Number of vacancies	Total planted
Dwarf yellow	4		3	7
Dwarf green	7		0	7
Dwarf red	5		2	7
King coconut	6		1	7
Rathran thembili	2		5	7
San Ramon (Russet)	7		0	7
San Ramon (Green)	7		0	7
Kamandala	6		1	7
Gon thembili	7		0	7
Nawasi	7		0	7
Bodiri	7		0	7
Pora pol	2		5	7
Ran thembili	7		0	7
Deekiri pol	7		0	7
Nawasi thembili	0		7	7
Dwarf green x tall	7		0	7
Dwarf yellow x tall	6		1	7

J.M.D.T. Everard and M.H.L. Padmasiri

Table 16. : *The status of the indigenous tall coconut conservation block at Bandirippuwa as at 31st December 2002 (Planted in 1984) and the San Ramon conservation in the adjoining block (Planted in 1986)*

Accession	Number of bearing palms	Number of young palms	Number of vacancies	Total
Ran thembili	26	4	8	38
Bodiri	35	0	45	80
Porapol	27	1	29	57
Nawasi	31	0	5	36
Kamandala	4	0	2	6
Gon thembili	53	1	16	70
Dikiri	1	0	2	3
San Ramon	148	0	14	162

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Table 17 : *The status of the dwarf palm conservation blocks at Bandirippuwa as at 31st December 2001 (Planted in 1987)**

Accession	Number of bearing palms	Number of young palms	Number of vacancies	Total planted
Dwarf green	44		29	73
Dwarf yellow	10		33	44
Dwarf red	28		71	99
Mirishena dwarf (1993)	4	16	13	41
Brazilian green dwarf (1993)	16	16	37	77
Dwarf brown (1993)	7			33
Dwarf brown (1993 at RE)	27			70

J.M.D.T. Everard, R. Jayatilaka and K Ekanayake

PROJECT : EVALUATION OF CONSERVED COCONUT GERMPLASM

Experiment B-8.5 : Evaluation of nine promising germplasm accessions at Nariyampotta division, Andigama farm, Giriulla (1994).

The experiment was initiated to carry out a systematic evaluation of the between and within population variability of a representative set of germplasm accessions conserved within the gene banks. For this purpose 9 germplasm accessions, which were diverse in their origins were selected and 15 half sib families of 5 each were planted per accession in a fully randomized design in January 1995 at Andigama Farm Giriulla. The status of flowering to date is given in table 18.

L. Perera and G K Ekanayake

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

King coconut seedlings rose from self pollination of selected parent palms at Marandawila, Walpita, Walahapitiya and Madampe were planted in two trial blocks at Raddegoda Estate, Delwita and Margaret Estate, Pallama in May and June 1999 respectively. In each population the king coconut palms, which are regular in bearing and producing nuts with desirable palatability were selected as parents and selfed for fixing these characters in the progeny.

Forty individuals each from Marandawila, Walpita and Walahapitiya along with the open pollinated control from Marandawila (40 seedlings) were planted at Raddegoda in a randomized block design with 10 seedlings/plot. Fifty four seedlings from Marandawila, 25 from Walpita, 45 from Walahapitiya, 25 from Madampe and 48 open pollinated (control) from Marandawila were planted in a fully randomized design at Pallama. These trials are progressing satisfactorily.

J.M.D.T. Everard, M H L Padmasiri, R B Attanayake and N Herath

Table 18 : *The status of flowering of the nine germplasm accessions planted at Andigama farm (NLDB), Giriulla (1994)*

Name of accession	Percentage of Palms in flower	Vacancies	Number of seedlings Planted
Maliboda	63%	32	60
St Anne's	80%	25	59
Ambakelle special	60%	32	71
Margaret	56%	32	76
Moorock	52%	29	72
Deberayaya	33%	30	85
Walahapitiya	55%	33	60
CRIC60	50%	26	87
Clovis	37%	19	60

Table 18 : *The status of planting in the new seed garden at Pallama as at 31st December 2003*

		Variety	Year(s) of Planting	Number of palms in flower	Number of vacancies	Seedlings Planted
Field 1	Seed palms	Tall	1998-2001	58	58	710
		San Ramon*		58	27	333
	Guard row	San Ramon		3	397	1145
		Total		**17**	**405**	**2188**
Field 2	Seed palms	Tall	1999-2002	44	70	1058
		San Ramon		43	82	529
	Guard row	San Ramon		0	240	2518
		Total		**18**	**343**	**4105**
Field 3	Seed palms	Tall	1999-2002	0	169	1236
		San Ramon		0	346	718
	Guard row	San Ramon		0	0	0
		Total		**0**	**515**	**1954**
Field 4	Seed palms	Tall	2002	0	122	1317
		San Ramon		0	0	0
	Guard row	San Ramon		0	0	0
		Total		**0**	**122**	**1317**
		Grand Total		**0**	**1385**	**9564**

1.2 Establishment of the Pallama Seed Garden

Establishment of Pallama Seed Garden (PSG) for mass production of CRISL98 was continued and during the year total of 1,317 *tall x tall* and 1,459 San Ramon seedlings were planted. Fifteen seedlings (12 San Ramon and 3 *tall x tall*) in Field 1 has attained flowering. Planting of *tall x tall* in a section of field 04 had to be postponed to allow continuation of the weed experiment of the Agronomy division for two more years.

Outside funded Projects

COGENT project for identification of farmer's varieties: A survey was conducted with the financial assistance of the COGENT to identify farmer's varieties of coconut in three regions, Galle, Wilpotha and Hettipola with the intention of *in situ* conserving traditional base planting material through community based nurseries. The project was successfully completed and the final report was submitted to the donors.

FAO project for molecular pathogen diagnosis: Proposed activities of the project were completed and the terminal report was submitted to FAO.

IFS project for identification of coconuts using DNA markers: The study is in progress but due to delay in purchasing primers the deadline could not be met. An extension was obtained till 31 January 2004 for completion.

Awards

Dr. L. Perera won a presidential research award for year 2002 for his research contribution on use of molecular markers in assessment of coconut genetic resources.

Extension activities

The annual one-day programme conducted for growers of both categories large and small sector on planting materials of coconut, planting technique and early care of seedlings, conducted at ISG, Ambakelle on 23rd May 2003. This was well attended in this year too with over 150 participants. The programme conducted with short lecturers and field demonstrations in order to convince the growers to adopt CRI recommended technology for increasing the coconut production and productivity in their lands.

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.

A team of GPB staff led by J.M.D.T. Everard visited Jaffna Peninsula on the request of RM, CCB Regional Office, Jaffna from 12 -15 February 2003 to identify seed coconut sources.

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

One Technical Officer and two Field Officers of the GPB staff were released on request of Head, CPD for mite control work by sulpher application in bags.

REPORT OF THE SOILS AND PLANT NUTRITION DIVISION

Actg. Head – N. A. Tennakoon, Ph D

1. GENERAL

In the Soils and Plant Nutrition Division, fourteen on going field experiments were continued and two new field experiments were commenced. The ongoing deep ground water survey, in the Kurunegala district, which was carried out under the CESS assistance was also continued during the year.

In the experiment on site-specific fertilizer recommendation at Mangala Eliya (S_2, DL_3), 30% increase in nut yield was observed from the palms receiving recommended dosage of Adult Palm Mixture (APM) over the control (no fertilizer). The difference was statistically significant. However, there was no further increase in yield due to the application of fertilizer doses that were higher than the recommended dosage. The results showed that the yield increase cannot be expected by applying more than the recommended dose of fertilizers, particularly on Borupan a series soil in the Dry Zone.

The experiment on fertilizer for king coconut palms at Walpita Estate, showed that the nut yield of palms receiving APM was 56% higher than that of the control, while the yields of palms received fertilizer equal to half of the recommended quantity of nutrient removal was 42% higher than that of the control (no fertilizer). These results were obtained six years after the commencement of the experiment. Based on results, the best fertilizer recommendation for king coconut palms is urea (N) 800 g, IRP (P) 600 g, MOP 1600 g and dolomite 1000 g per palm/year, which is equivalent to APM for annual application.

Experiment on comparison of organic and green manure with inorganic fertilizer (APM), showed that the nut yield of the palms receiving poultry manure was increased by 36% compared to the control (no fertilizer). With cattle manure, goat manure and gliricidia, the yield increases were 31%, 33% and 15% over the control respectively while the yield increase by recommended inorganic fertilizer (APM) was 28%. Results indicated that application of organic manures such as poultry manure, goat manure and cattle manure is economically more beneficial than inorganic fertilizer.

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. However it is too early to make a recommendation. The yield difference between the above two treatments were 11 nuts/palm/year, while it was 6 nuts/palm/year between sodium chloride and control (no fertilizer) treatments.

Drip irrigation experiment conducted at Ratmalagara Estate showed 71% yield increase compared to control (no irrigation). This was observed after applying 40 l/day/palm at 6 days interval, with 250 g of APM plus 83 g of dolomite throughout the year at monthly intervals.

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 based 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 belongs to the land suitability class S_4.

Treatments were as follows.

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

Treatments	Total P_2O_5 %	Rate of application g/palm/yr
TSP	46	350
IRP	27.5	600
ERP	30	600
Control (No P source)	-	0

Basal application -	Urea (46% N)	800 g/palm/yr
	Muriate of potash (60% K_2O)	1600 g/palm/yr
	Dolomite (20% MgO)	1000 g/palm/yr

Leaf samples from 14th frond of each treated palms were taken in October 2003. Fertilizer application was carried out in October. Nut yield from December 2002 to December 2003 did not show any significant difference among the treatments (Table 2). Generally, nut yield of all plots was as low as 27 - 35 nuts per palm per year (Table 3). This may be due to the combined effect of shallow soil depth and the drought prevailed during the year.

Table 2 : *Nut yield of the experiment*

Treatment levels	Nut yield (per palm per year)
TSP	33
IRP	35
ERP	32
Control (No P sources)	27
Level of significance	ns

The leaf nutrient levels did not show any significant difference among the treatments except K. N, P and K levels were above the critical level (N > 1.9%, P > 0.11% and K > 1.2%) but the leaf Mg in some palms was below the critical levels (Mg > 0.25%). See table 3.

Table 3 : *Nutrient concentrations in the 14th leaf*

Treatment levels	N%	P%	K%	Mg%
TSP	2.70	0.15	1.34	0.26
IRP	2.54	0.15	1.38	0.23
ERP	2.59	0.15	1.24	0.23
Control (No P source)	2.58	0.14	1.22	0.22
Level of significance	ns	ns	*	ns
LSD (p 0.05)	-	-	0.02	-

Experiment : Evaluation of residual P availability in the soil after long term rock phosphate application

Pot Experiment : 1

The objective of this experiment was to evaluate the phosphorus availability in Andigama series soils (lateritic gravel in the Intermediate zone) after ten years on annual and continuous application of different levels of Eppawela Rock Phosphate, Saphos Phosphate and Triple Super Phosphate.

Two pot experiments were established to study the plant response to residual phosphorus content in the soil. Ginger (*Cingiber opisonarlae*) and *Panicum maximum* were used as the indicator plants. The soil samples for this experiment were taken from the manure circles of the palms in experiment 6.0.1 at Ratmalagara Estate. The soil samples have received phosphate applications over the last 10 years as follows (Table 4).

Table 4 : *The cumulative phosphate doses received by soils with different phosphate sources*

Treatment levels		Cumulative phosphorus fertilizer dose from 1991-2001 g/kg soil
TSP	1	0.379
	2	0.717
	3	1.434
SP	1	0.599
	2	1.197
	3	2.394
ERP	1	0.549
	2	1.096
	3	2.193
Control		-

This experiment was a Randomized Bock Design with three replicates. Pots filled with 6 mm mesh sieved 3.5 l of respective soil samples.

Ginger rhizomes were planted in each pot under Experiment – 1. Each soil samples were treated with a basal dose of 10 g urea and 20 g muriate of potash as split doses for 6 months during the growing period of ginger.

Table 5 shows P status of phosphorus pre treated soils for ten years.

According to Table 5, among the soils used for the pot experiment, SP and ERP treatments had significantly higher values for 2.5% acetic acid extraction than both TSP and control. It follows that both SP and ERP treated soils contained significantly higher quantities of basic Ca-P fraction (apatite – P) than both TSP treated soil and control. Further, the high significant difference in 2.5% acetic acid extractable P between treatments, TSP level 2 and 3 and the control indicated that a considerable portion of TSP have been converted to basic-P. According to Olsen-P value; only TSP treatments showed significantly high values compared to control and both ERP and SP treatments indicating that a considerable amount soluble Ca-P and Al-P is present in TSP treatment than the others. This was confirmed by the P values obtained for the Bray and Kurtz extraction also.

Table 5 : *Available phosphorus status of the ten years phosphate treated soils that were used for the experiment*

Treatment levels	P (mg/kg)		
	Bray & Kurtz	Olsen	2.5% Acetic acid
TSP 1	111.42 ±59	32.96 ± 6	27.75 ±13
2	261.60 ±141	126.13 ± 64	100 ± 62
3	442.92 ± 215	138.20 ± 2	139 ± 19
SP 1	33.55 ± 10	15.71 ± 4	90.58 ± 55
2	65.43 ± 11	15.28 ± 4	151.47 ± 11
3	83.52 ± 10	13.79 ± 3	458.68 ± 85
ERP 1	28.61 ± 9	9.46 ±1	135.33 ± 23
2	27.01 ± 5	11.07 ±3	252.80 ± 97
3	31.85 ± 4	8.04 ±1	438.38 ±38
Control	13.01 ±0.8	5.60 ±1	6.09 ± 0.8
Level of significance			
Cont. vs phosphate sources	P 0.05	P 0.01	P 0.001
Between phosphate sources	P 0.001	P 0.001	P 0.001
Between TSP levels	P 0.001	P 0.001	ns
Between SP levels	ns	ns	P .001
Between ERP levels	ns	ns	P 0.001
LSD			
Cont. vs phosphate sources	104.3	25.9	68.8
Between phosphate sources	80.8	20.0	53.3
Between TSP levels	139.9	34.7	-
Between SP levels	-	-	92.3
Between ERP levels	-	-	92.3

Each of the above soil samples was filled in a pot and ginger was planted in triplicate. Growth parameters of ginger plants such as the number of tillers per bush, the height and the number of leaves in each pot were recorded.

Six months after planting, ginger plants were up-rooted and fresh and dry weight of vegetative parts of the plants, roots and rhizomes were recorded (Table 6). After removing ginger plants from pots, chemical analyses of rhizomes, roots, vegetative parts of the ginger plants for total P (Table 7) and soil samples for available P were performed.

There was a significant increase in dry weight of rhizomes between all three-phosphate sources and the control. However, the differences were significant only for TSP-3, SP-2, SP-3, ERP-3 only. There was also significant increase in dry weight of rhizomes between TSP-3 and both TSP 1 and 2 levels.

The response in terms of dry weight of vegetative parts was not significant between all the phosphate sources and the control or among phosphate sources. However, significant increase in the weight of vegetative parts with the increasing level of TSP and SP treatments was observed (Table 6). The observation was similar for the dry weight of roots (Table 6). The total P content in the plant was an indication of the P uptake by ginger in response to different treatments. The total P in the plants in the control plots were not significantly different from that of all other P sources. However, there was a significant increase in P content in the plants of TSP-3 and SP-3 compared to lower levels of the respective sources (Table 7).

Table 6 : *Dry weight of rhizomes roots and vegetative parts of the Ginger in response to different treatments*

Treatment levels		Rhizome (g)	Roots (g)	Vegetative Parts (g)
TSP	1	4.86 ±2	1.12 ± 0.48	5.23 ± 0.7
	2	5.17 ± 2	1.79 ± 1.43	8.31 ± 0.3
	3	9.87 ± 1	2.84 ± 0.62	15.05 ± 3.4
SP	1	5.27 ± 2	1.25 ± 0.21	3.83 ± 3
	2	8.17 ± 1	2.04 ± 0.34	8.37 ± 0.9
	3	8.39 ± 2	3.12 ± 0.96	14.64 ± 5
ERP	1	4.38 ± 0.8	1.89 ± 0.95	7.46 ± 3
	2	6.15 ± 0.5	2.24 ± 0.48	7.89 ± 2
	3	8.05 ± 2	2.58 ± 0.85	9.50 ± 4
Control		3.51 ± 0.16	2.30 ± 0.33	3.21 ± 0.1
Level of significance				
Cont. vs phosphate sources		P < 0.05	ns	ns
Between phosphate sources		ns	ns	ns
Between TSP levels		P < 0.05	P < 0.05	P < 0.05
Between SP levels		ns	P < 0.05	P < 0.05
Between ERP levels		ns	ns	ns
LSD				
Cont. vs phosphate sources		3.1	-	-
Between phosphate sources		-	-	-
Between TSP levels		3.4	1.3	6.9
Between SP levels		-	1.3	6.9
Between ERP levels		-	-	-

Table 7 : *Phosphorus content in Ginger plants in response to different treatments*

Treatment levels		Phosphorus content (mg/plant)
TSP	1	11.00 ± 3
	2	21.00 ± 15
	3	43.67 ± 15
SP	1	8.33 ± 8
	2	17.00 ± 2
	3	41.67 ± 15
ERP	1	20.00 ± 14
	2	16.67 ± 7
	3	23.00 ± 12
Control		10.00 ± 3
Level of Significance		
Between TSP levels		p ≤ 0.01
Between SP levels		p ≤ 0.05
LSD		
Between TSP levels		0.08
Between SP levels		0.08

The overall results showed that the highest level of each phosphate treatment (level 3) was effective in increasing the weight of rhizome and the vegetative parts. The effect on root weight was not significant. Although soil analysis showed a high quantity of available P in all

treatments, the response of ginger in terms of growth parameters was significant for P treatment level 3 in all three sources. In the case of TSP, this could be due to high P fixation in the Andigama series soils and on the other hand, in case of ERP and SP, it could be due to the low solubility of apatite.

In the Experiment – 2. *Panicum maximum* cuttings were planted in each pot in the Experiment 2. The basal treatments were; N at the rate of 0.18 g of Urea, K at the rate of 0.36 g of muriate of potash and Mg at the rate of 0.28 g Epsom salt. Grass was cut at two months intervals for one year to measure the vegetative growth. Dry weight of cumulative grass cuttings are given in Table 8.

Table 8 : *Cumulative dry weight of Panicum maximum cuttings during the year*

Treatment	Cumulative dry weight
TSP1	7.23 ± 2.02
TSP2	6.56 ± 1.69
TSP3	8.14 ± 2.02
SP1	8.41 ± 2.31
SP2	7.74 ± 0.60
SP3	8.86 ± 1.57
ERP1	5.70 ± 1.11
ERP2	6.04 ± 1.32
ERP3	8.22 ± 1.89
Control	5.84 ± 1.11
Level of Significance	ns

There was no significant difference in cumulative dry weight of *Panicum* cuttings (5 cuttings) between control and the different P sources treated plants. Chemical analysis of grass cuttings is in progress.

D M D I Wijebandara, L L W Somasiri and C P A Kurundukumbura

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 weak acidic or neutral soils of the Dry zone.

Pot Experiment 1

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 soil samples from the Dry zone and one soil sample 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

Soil samples filled in pots (6 kg soil/pot) and treatments were 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 phosphate fertilizer rates were calculated 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 the require for a coconut palm per year.

All the pots were treated with the basal dose 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.

Pots were watered according to the rainfall pattern existing in the location of the soil sampling. Leached water samples were collected weekly. Soil samples were collected from each pot two weeks, one month and three months intervals for one year respectively.

Solubility of phosphate sources used for the experiment are given as follows.

	Water soluble P_2O_5%	50% HCl soluble	2% Citric acid soluble
HERP	0.013	39.69	4.33
ERP	0.0106	38.20	3.84
IRP	0.00099	29.89	6.61

Chemical properties of the soils used for the pot experiment are given in Table 9.

Table 9 : *Total P, Available P (Olsen's bicarbonate) pH and chemical properties of four soil samples used for the pot experiment*

Soil series	pH (1:5) H_2O	Total P mg/kg	Available P (Olsen's bicarbonate) mg/kg
Boralu series	5.58	195.35	18.24
Ganbura series	5.89	93.62	26.79
Mumpuri series	6.64	77.41	47.88
Elayapattuwa series	6.00	176.31	49.78

Available phosphorus content was higher in both Mampuri series and Elayapattuwa series soils than the Boralu and Gambura series soils.

Soluble phosphorus concentrations in leached water through the pots during one year period, are given in Table 10.

Table 10 : *Soluble P content in leached water*

Treatments	Soil series			
	Boralu P (mg)	Gambura P (mg)	Mampuri P (mg)	Elayapattuwa P (mg)
TSP	0.91 ± 0.25	1.34 ± 0.22	63.6 ± 7.59	1.42 ± 1.4
IRP	0.94 ± 0.06	0.66 ± 0.15	2.84 ± 0.56	0.53 ± 0.09
ERP	0.79 ± 0.05	0.65 ± 0.17	3.12 ± 0.13	0.46 ± 1.17
HERP	2.08 ± 2.01	0.58 ± 0.14	3.71 ± 1.54	0.53 ± 0.08
Control	1.05 ± 0.22	0.44 ± 0.02	4.19 ± 0.18	0.80 ± 0.3
Significance	ns	P 0.01	P 0.001	ns
LSD (P 0.05)	-	0.32	6.17	-

The results showed that a very high fraction of P from TSP has leached from Mampuri series soils compared to other soils. The Mampuri is a sandy soil, while all the other soils are sandy clay loam. The very low quantities of P in the leachates of other soils indicate the very high P fixation in those soils and very low downward movement of P.

Available P (Olsen's bicarbonate) content in different soils in different times after treatment application are given in Table 11.

Table 11 : *Available Phosphorus concentration (Olsen's bicarbonate) mg/kg in soils in response to different treatments*

Soil series	Time					
	2 weeks	4 weeks	8 weeks	12 weeks	16 weeks	28 weeks
TSP	20.4± 9.83	22.10± 6.28	18.90±10.28	19.88± 8.78	19.46 ± 6.34	15.89 ± 7.99
SP	8.89± 5.06	14.57± 2.88	16.00± 7.90	11.62± 5.36	13.49± 4.55	7.67± 4.36
ERP	8.61± 4.95	14.38± 6.68	15.77± 9.48	10.98 ± 4.62	11.62± 5.12	8.13± 4.96
HERP	11.13± 6.40	13.64± 4.06	14.55± 7.94	10.88± 4.76	12.03± 5.36	7.36± 4.59
Cont.	8.68± 3.82	12.76± 4.87	14.33± 6.87	10.72± 4.79	12.41± 6.31	7.90± 4.09
Level of significance	***	***	***	***	***	***
LSD	1.77	2.80	3.45	3.13	2.39	2.43

Pot Experiment II

A green house pot experiment was established with all four soil samples to quantify the soluble phosphorus content by indicator plant, *Panicum maximum*. Soils filled into pots (400 g soil/pot) and *Panicum* cuttings were planted after treatment. The experiment was set up as a Randomized Complete Block Design with three replicates.

Treatments were as follows.

T_1 - Control (no phosphorus fertilizer)
T_2 - TSP, 0.073g/pot
T_3 - IRP, 0.12 g/pot
T_4 - ERP, 0.12 g/pot
T_5 - HERP, 0.094 g/pot

Phosphorus fertilizer rates based on the same as pot experiment I.

All the pots were treated with a basal dose of N at the rate of 0.16 g of urea, K at the rate of 0.32 g of MOP and Mg at the rate of 0.25 g of Epsam salt.

Panicum shootings were cut at one month intervals for one year and dry weight of cuttings were recorded. Chemical analysis for phosphorus content in vegetative part of the Panicum is given in the Table 12.

Table 12 : *Cumulative dry weight of grass cuttings of treated plants*

Soil series	Cumulative dry wt.	Treatment	Cumulative dry wt.
Boralu	6.5092	TSP	7.3721
Gambura	4.4099	SP	6.4187
Mampuri	5.8164	ERP	5.7790
Elayapattuwa	7.8394	HERP	6.0425
		Control	5.1063
Level of Significance	***		**
LSD	1.0797		1.2072

Cumulative dry weight of vegetative parts of Panicum showed a significantly higher value for Elayapattuwa soil series and lowest for Gambura soil series.

TSP and SP treated plants showed significantly higher cumulative dry weight than ERP, HERP treated plants and control.

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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 WL3. The site falls into land suitability class S_4 and 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/yr), T_3 - potassium sulphate (1.8 kg/palm/yr), T_4 - sodium chloride (1.2 kg/palm/yr) and T_5 - sodium sulphate (1.45 kg/palm/yr). 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 13. There were no significant differences in nut yield among the treatments up to 2003

Table 13 : *Nut yield of the experiments at Wayagolla site in 1997 – 2002 and 2003.*

Treatments	Nuts (palm/year)	
	1997 – 2002 cumulative	2003
T_1 (No Fertilizer – Control)	330	52
T_2 (Muriate of potash)	390	69
T_3 (Potassium sulphate)	371	67
T_4 (Sodium chloride)	344	58
T_5 (Sodium sulphate)	391	65
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 sodium chloride, the difference was not statistically significant. The yield difference between the above two treatments were 11 nuts per palm per year, while it was 6 nuts per palm per year between sodium chloride and control (no fertilizer) treatments.

The nutrients contents of the leaf, such as K, Mg, Ca and Na have shown significant differences among the treatments. Leaf P and other micronutrients were not shown any significant differences among the treatments. Eventhough P has not shown any significant differences among the treatments, the P values are in the sufficiency range (P > 0.11%) (Table 14).

Table 14 : *Leaf nutrients in the 14th leaf*

Treatments	P %	K %	Ca %	Mg %	Na %	Fe (mg/kg)
T_1	0.149	1.09	0.39	0.20	0.17	119
T_2	0.140	1.34	0.35	0.19	0.13	92
T_3	0.140	1.48	0.31	0.18	0.15	91
T_4	0.140	0.68	0.40	0.27	0.37	96
T_5	0.144	0.91	0.35	0.21	0.32	82
Level of Significance	ns	p 0.01	p 0.05	p 0.001	p 0.01	ns
LSD (P<0.05)	-	0.29	0.051	0.023	0.11	-

Considering soil parameters, soil K and soil Mg levels have shown significant differences among the treatments (Table 15).

Table 15 : *Soil nutrients status*

Treatment	Depth (cm)	K %	Mg %	Ca %	Na %
T_1	0 - 20	0.1844	0.5655	1.099	0.2055
	20 - 40	0.1544	0.3111	1.6155	0.2100
	40 - 60	0.1500	0.2767	1.8511	0.4333
T_2	0 - 20	0.2131	0.4083	2.4524	0.1750
	20 - 40	0.2989	0.6455	1.6983	0.1694
	40 - 60	0.2411	0.5378	1.4922	0.2400
T_3	0 - 20	0.3033	0.6122	1.5822	0.1378
	20 - 40	0.3034	0.5033	1.3479	0.1322
	40 - 60	0.3044	0.3622	0.96667	0.1355
T_4	0 - 20	0.1067	0.8822	2.4778	0.2278
	20 - 40	0.1000	0.5967	1.5588	0.2089
	40 - 60	0.0755	0.4155	1.0155	0.1978
T_5	0 - 20	0.1722	0.8078	2.4711	0.1811
	20 - 40	0.1111	0.5811	1.6644	0.2544
	40 - 60	0.0800	0.3489	0.7522	0.2222
Level of Significance		p 0.001	p 0.05	ns	ns
LSD (P < 0.05)	Treatment	0.2691	-	-	-
	Depth	-	0.2085	-	-

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 16.

Table 16 : *Treatment combinations and nut yield of the experiment*

Treatments	g/palm/y	Mean yield nuts/palm/year
N (Urea 46% N)		
N_1	0	36 ± 11
N_2	600	38 ± 9
N_3	1200	39 ± 8
K (Muriate of potash 60% K_2O)		
K_1	0	34 ± 6
K_2	1200	36 ± 10
K_3	2400	43 ± 10
Mg (Kieserite 24% MgO)		
Mg_1	0	36 ± 10
Mg_2	750	37 ± 10
Mg_3	1500	39 ± 10
Level of Significance	-	ns
Basal Phosphate application Imported Rock Phosphate 600 g/palm/yr		

The nut yield of the experiment has not shown any significant difference among the treatments. The yield per palm remained as low as 36-43 nuts/palm in the year 2003 probably due to the dry period prevailed in the year (Table 16). Eventhough there is no significant differences, the highest K level applied palms have shown higher nut yield than the high level of N and Mg treatments.

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Experiment 7.0.3 : *Formulation of a suitable fertilizer recommendation for king coconut (1997)*

This experiment, on a Randomized Block Design with 4 replicates and 3 palms per plot and six treatments were established on adult king coconut palms in 1997 at the following two locations.

Since the palms at Marandawila site have not shown any significant response to the treatments either in terms of nut yield or nutrient uptake the experiment was terminated at the end of the year 2002. The experiment at Walpita was continued up to year 2003.

Expt. No.	Location	Agro-ecological region	Soil type region	Land Suitability Class
7.0.3.1	Marandawila	IL_3	Imperfectly drained, deep loamy sand (Palugaswewa series)	S_2
7.0.3.2	Walpita	WL_3	Well drained, moderately deep gravelly loam (Boralu series)	S_4

Eventhough nut yield have not shown any significant differences, the nut yield of the palms receiving APM was 56% higher than the control while that of palms receiving fertilizer equal to half of the quantity of nutrient removal was 42% higher than the control (no fertilizer). This result was obtained six years after the experiment (Table 17). According to the results it can be concluded that the best recommendation for king coconut is Urea (N) 800 g, Imported Rock Phosphate (P) 600 g, Muriate of Potash 1600 g and Dolomite 1000 g per palm which is the same as APM for annual application.

Table 17 : *The nut yields at Walpita site*

Treatment	Cumulative yield from 1998 – 2001	2003
T_1	482	119
T_2	485	170
T_3	508	167
T_4	457	167
T_5	482	187
T_6	504	167
Level of Significance	ns	$P < 0.05$
LSD (< 0.05)	-	26

The final leaf sampling was carried out in December 2003. The analysis is in progress. The leaf nutrients carried out in June 2003 were not significant among the treatments except Mg (Table 18). However, the major nutrients such as N and P are in the sufficiency range (N 1.9%, P 0.113%). Considering K, it has shown little below values of the sufficiency range (K 1.2%) in some treatments. However the best nut yield given by palms (Treatment 5: APM) have shown above sufficiency level of leaf K.

Table 18 : *Leaf nutrient levels in the 14th leaf*

Treatment	N%	P%	K%	Mg%	Ca%	Na%	Fe	Mn	Cu	Zn
T_1	2.13	0.119	0.98	0.21	0.21	0.074	70.8	302	8.68	29.7
T_2	2.13	0.120	1.16	0.26	0.21	0.04	79.5	300	9.28	33.2
T_3	2.25	0.121	1.12	0.25	0.21	0.04	59.8	287	9.23	21.7
T_4	2.22	0.123	1.11	0.27	0.21	0.06	73.1	353	8.35	30.0
T_5	2.30	0.121	1.27	0.28	0.21	0.04	70.2	303	9.23	43.5
T_6	2.15	0.123	1.20	0.26	0.18	0.04	80.1	302	9.01	27.9
Level of significance	ns	ns	ns	P 0.05	-	-	-	-	-	-
LSD (p 0.05)	-	-	-	0.03	-	-	-	-	-	-

T_1 – Control – no fertilizer; T_2 – ½ NPK removal/year; T_3 – ¾ times NPK removal/year; T_4 – NPK equal to removal/year;
T_5 – APM ; T_6 – 1 ½ times APM

The N, P, K and Mg levels in the palms treated with APM have shown the highest values compared to the other treatments. This clearly showed that the major nutrients supplies by annual application of APM have enough nutrients to maintain the highest nut yield during the year.

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

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

The objectives of this experiment were to test the response of coconut palms in 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, was established with 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	2000	S_2

The treatments for the all sites are given in Table 19.

Table19 : *Treatment combinations in the experiment (g/palm/yr)*

Treatments	Urea	SP/ERP	MOP	Dolomite
T_1	0	0	0	0
T_2	800	600	1600	1000
T_3	1100	825	2200	1375
T_4	1400	1050	2800	1750
T_5	1700	1225	3400	2125

Experiment 7.1.2.1 : *Sirivasa Estate, Mangala-eliya*

Thirty percent nut yield increase was obtained from the palms that received recommended APM over control (no fertilizer) palms (Table 20). The difference was statistically significant. However, there was no further increase in yield, by the increased application of fertilizer doses that were higher than the recommended dose. The results showed that the yield increase cannot be expected by applying more than the recommended fertilizer rates particularly on Borupan a series soil in the Dry zone.

Table 20 : *The nut yield of Mangala-eliya site*

Treatment	Cumulative nut yield 2001-2002	Nut yield (palm/year) 2003
T_1	123	83
T_2	152	108
T_3	143	102
T_4	144	105
T_5	139	101
Level of Significance	P 0.001 in 2001	P 0.05
LSD (P 0.050)	12	17

Leaf nutrients were not shown any significant differences among the treatments. (Table 21).

Table 21 : *Leaf nutrient levels of the 14th leaf*

Treatments	N%	P%	K%	Mg%	Ca%
T_1	2.34	0.147	1.12	0.32	0.38
T_2	2.17	0.152	1.20	0.31	0.43
T_3	2.36	0.149	1.19	0.28	0.37
T_4	2.20	0.153	1.17	0.31	0.41
T_5	2.05	0.148	1.15	0.28	0.40
Level of Significance	ns	ns	ns	ns	ns
LSD (p 0.05)	-	-	-	-	-

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

Experiment 7.1.2.2 : *Naiwala*

The leaf samples before the fertilizer application were taken in October and the 1st different treatment combinations were applied in November.

Experiment 7.1.2.3 : *Kobeigane*

The leaf sampling before the fertilizer application was carried out in September and the 1st different treatments combinations were applied in December 2003.

Experiment 7.1.2.4 : *Sirigampola*

The leaf sampling before the fertilizer application was carried out in August and the 1st different treatment combinations were applied in November 2003.

Experiment 7.1.2.5 : *Wellawa*

To represent Kurunegala soil series, a new site was selected at Wellawa. Mapping of area and demarcating the plots were completed in March 2003 and preliminary nut yield recording was carried out during the year.

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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 were determined monthly.

The dry weight of different components removed from a coconut palm in Boralu series soil over the period of 4 years is given below in Table 22.

Table 22 : *The dry weight of different components removed from a palm in Boralu series soil over the period of 4 years*

Year	No. of nuts/palm	Dry wt. of nuts kg/palm	No. of fronds/palm fallen	Dry wt. of fronds kg/palm	Inflorescence button nuts immature kg/palm	Total kg/palm
2000	55	50	6	18	10	78
2001	72	54	12	34	14	102
2002	20	11	4	13	8	32
2003	34	-	5	-	-	-

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Experiment 7.2.3 : *Determination of micronutrient status of coconut palms on major soil series under different fertilizer practices*

For this study, leaf and soil samples were collected from coconut lands managed with different fertilizer practices. The sites were selected to represent major soil series in the coconut triangle. Several locations were selected from each soil series. The soil series, the locations and the fertilizer practices at each site are given in Table 23.

Table 23 : *Sampling locations for micronutrient studies*

Soil series	Location	Fertilizer practices		
Kalpitiya	Talawila, Palakuda, Kadayamatte, Daluwa, Seetapola, Theheliya, Kurinchipitiya	Organic	Inorganic	No Fertilizer
Weliketiya	Thoduwawa, Talwila, Kattantivu, Setapola, Pujapitiya, Marawila, Thoduwawa, Watawana, Ambakandawila , Udappuwa, Chilaw, Panapitiya	Organic	Inorganic	No Fertilizer
Pallama	Walpita, Gaspe	Organic	Inorganic	
Wilaththawa	Galmuruwa	Orgajic		
Katunayaka	Katunayaka, Kadirana		Inorganic	No Fertilizer

Ctd... Table : 23

Soil series	Location	Fertilizer practices		
Rathupasa	Marawila, Mahawewa		Inorganic	No Fertilizer
Dummalasuriya	Kattimahana, Horombugama	Organic	Inorganic	No Fertilizer
Boralu	Walpita, Gaspe, Banduragoda, Wattemulla,	Organic	Inorganic	No Fertilizer
Kurunegala	Pahamunae			
Kuliyapitiya	Pahamunae	Organic	Inorganic	No Fertilizer
Madampe	Galmuruwa, Sirigampola, Mahawewa, Dematapitiya, Karukkuwa, Kirimetiayana, Marawila, Katuneriya, Mudukatuwa, Madampe, Kakkapalliya, Thalawila, Pambala, Milawa, Walahapitiya	Organic	Inorganic	No Fertilizer
Wariyapola	Hettipola, Ibbagamuwa, Peddawa, Nikadalupotha, Kanaththegama, Ganewatta, Warawala	Organic	Inorganic	No Fertilizer
Andigama	Henegedara, Dumalasuriya, Welipannagahamulla, Rathmalagara, Nattandiya, Hawana, Kachchakaduwa	Organic	Inorganic	No Fertilizer

There were no significant differences of leaf micronutrient concentrations among sites receiving different fertilizer application practices (Table 24). Fe concentrations in the 14th frond was above the respective critical levels (> 40 mg/kg and 60 mg/kg respectively. However, the Cu and Zn concentrations of the 14th frond were below the critical level (< 5 mg/kg and 30 mg/kg respectively) irrespective of the fertilizer practices. The leaf analysis showed Fe, Mn and Zn concentrations in leaf increase with increase of leaf age. But the Cu concentration showed a decrease with increase of leaf age.

Table 24 : *Micronutrient concentrations of different leaf ranks of palms receiving different fertilizer treatments - Means of 25 sites*

Fertilizer Practice	Leaf Rank	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
Organic	1st	35.69 – 112.8	18.9 – 14.8	2.66 – 7.62	13.8 – 38.8
		53.88 ± 19.32	52.01±27.73	5.06±1.25	20.73±5.02
	6th	56.80 – 190.4	25.4 - 325	2.94 – 8.02	13.4 – 35.3
		96.42 ± 33.99	126.7±73	4.92±1.09	21.36±4.53
	14th	58 – 428.8	27.8 - 472	2.77 – 7.59	16 – 49.1
		127.69±81.75	187.15±123.27	4.28±0.99	24.17±6.36
Inorganic (N P K & Mg)	1st	34 – 123.4	127 - 150	2.76 – 9.36	11.9 – 34.2
		57.15±19.71	63.07±40.01	5.56±1.53	20.18±5.95
	6th	52.5 – 160.49	23.4 - 288	3.25 – 7.71	12.81 – 39.1
		94.97±29.6	122.86±75.52	5.32±1.35	21.56±5.82
	14th	60.2 – 257.7	22.1 - 437	2.39 – 7.81	15.7 – 36.3
		121.57±58.46	154.2±107.8	4.58±1.43	24.85±5.84
No fertilizer application	1st	40.3 – 178.8	9.89 - 161	3.89 – 8.29	13.8 – 42.7
		67.93±35.78	75.86±48.85	6.06±1.28	25.67±8.93
	6th	59.2 – 381.8	19.3 - 277	2.66 – 6.42	18.1 – 36.1
		127.23±85.88	138.04±87.99	4.74±1.03	27.33±5.35
	14th	76.8 - 593	18.6 - 435	2.13 – 8.1	22.4 – 41.
		170.79±136.69	206.35±	4.10±1.36	31.36±10.94

Generally, coconut palms receiving no fertilizer, though differences were not significant, showed slightly higher values Fe, Mn and Zn compared to palms receiving organic or inorganic manure. This trend was not seen in case of Cu.

There was no significant difference in soil micronutrient levels in respect to different management practices. The variations in concentration of all four nutrients within a soil depth were very high as indicated by standard deviation. The CV ranges from 20-50% for all the values. In general, the availability of Fe, Mn, Zn and Cu in the soil did not show any relationship to fertilizer application (Table 25).

Table 25 : *Micronutrient concentrations (mg/kg) of soils in the manure circle and the centre of square in respect to different fertilizer practices*

Fertilizer Practice	Position to the coconut land	Soil depth	Fe	Mn	Cu	Zn
Organic	Manure circle	Top soil (0-25 cm)	6.03-85.3 3.04±38.9	1.81-62.4 10.17±12.8	0.17-1.34 0.62±0.36	0.51-5.72 1.83±1.51
		Sub soil (25-50 cm)	7.11-70.35 27.43±20.61	1.25-65.75 9.77±15.72	0.14-1.58 0.60±0.38	0.22-3.07 1.17±0.97
	Centre of square	Top soil (0-25 cm)	1.35-57.4 23.32±15.75	0.91-63.85 10.02±15.13	0.18-1.76 0.56±0.43	0.13-2.15 0.83±0.49
		Sub soil (25-50 cm)	4.42-46.81 17.51±9.97	0.75-34.9 8.19±12.41	0.15-1.57 0.56±0.36	0.22-1.93 0.66±0.47
Inorganic	Manure circle	Top soil (0-25 cm)	9.83-121.16 33.87±28.79	0.58-50.35 12.51±15.41	0.09-2.31 0.57±0.45	0.13-4.92 1.35±1.40
		Sub soil (25-50 cm)	105.-157 41.81±36.73	0.55-50.55 11.94±13.81	0.21-2.17 0.61±0.44	0.16-2.31 0.88±0.95
	Centre of square	Top soil (0-25 cm)	7.6-95.9 24.19±19.3	0.96-54.25 14.19±14.43	0.14-2.13 0.59±0.42	0.11-5.65 0.91±1.15
		Sub soil (25-50 cm)	6.32-44.98 16.82±10.49	0.34-56 13.64±14.11	0.14-1.82 0.58±0.37	0.12-3.13 0.72±0.82
Neglect	Manure circle	Top soil (0-25 cm)	3.92-140.15 37.26±33.33	0.67-23.58 9.97±10.52	0.3-0.91 0.6±0.18	0.50-10.05 1.64±2.3
		Sub soil (25-50 cm)	9.01-89.1 26.02±19.21	0.36-13.25 7.42±10.46	0.29-1.59 0.71±0.31	0.21-3.47 1.13±0.9
	Centre of square	Top soil (0-25 cm)	2.92-46.75 23.3±11.98	0.64-32.55 8.00±8.74	0.31-0.92 0.64±0.17	0.21-3.04 1.07±0.72
		Sub soil (25-50 cm)	2.94-42.65 - 78±9.69	0.41-32.4 8.24±9.09	0.34-1.12 0.62±0.21	0.16-2.71 0.71±0.58

There was a significant increase in Fe and Zn contents in manure circle soils than centre of square soils irrespective of fertilizer practices. It appears that the interaction between the roots and soil may result in enhancing the micronutrient availability in soils (Table 26).

Table 26 : *Fe and Zn concentration in manure circle and centre of square soils*

Position of the coconut land	Zn (mg/kg)	Fe (mg/kg)
Manure circle	1.38 ± 0.11	33.56 ± 2.18
Centre of square	0.85 ± 0.11	21.36 ± 2.17
Level of significance	$p \leq 0.001$	$p \leq 0.001$
LSD		

In case of Zn there was a significant increase in the concentration of top soils than sub soils irrespective of fertilizer management (Table 27).

Table 27 : *Zn concentration in top (0-25 cm) and sub soils (25-50 cm)*

Soil depth	Zn (mg/kg)
Top soil	1.31 ± 0.11
Sub soil	0.92 ± 0.11
Level of significance	$p \leq 0.001$
LSD	

Table 28 : *Correlation between Cu concentration of the soil and 1st leaf of coconut palms in organic fertilized sites*

Leaf rank	Manure circle (Sub soil)	Center of square (Top soil)	Center of square (Sub soil)
1st	r = 0.6218	r = 0.5772	r = 0.5811

r = Correlation co-efficient

There was a correlation between Cu concentration of organic fertilized sub soil of manure circle and top and sub soils of centre of square of the coconut palms and 1st leaf of the same palms (Table 28).

Generally there was no correlation between the leaf concentration and the soil concentration of any of the four micronutrients. However, Cu concentration of the 1st leaf showed a weak correlation with 25.

The overall results showed that there was considerable increase in the availability of all four nutrients in the manure circle compared to the center of the square irrespective of fertilizer practices. It implies that, some reactions take place in the root zone to increase the micronutrient availability in the soil. When the manure circle and the center of square values are compared, no evidence were found on depletion of natural Fe, Cu, Zn and Mn concentration in the soil due to coconut plantation. However, leaf concentrations of Cu and Zn of all the palms used for this study were lower than the sufficiency levels given by other countries (<5 ppm and <30 ppm) which needs further investigation. The question is whether the natural availability of Cu and Zn in coconut soils are sufficient for coconut plantations. An experiment conducted at Ratmalagara Estate and Pottukulama Estate showed that application of $CuSO_4$ and $ZnSO_4$ at 200 g and 400 g per palm per year respectively did not increase the Cu and Zn levels of the 14th leaf concentration above 6 ppm and 28 ppm respectively.

D M D I Wijebandara and L L W Somasiri

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 Design with 3 replicates and five treatments plots was established in 1999 at Pottukulama Research Station.

The same experiment, on a Restricted Randomized Grouped Block (Complete) Design with single palm per treatment within a block, four treatments per block, three blocks per group with six groups was established in 2002 at Bandirippuwa Estate.

Expt No.	Location	Agro-ecological Region	Soil type	Land suitability class
9.0.2.1	Pottukulama Research Station	IL_3	Sandy loam (Welipelessa series)	S_2
9.0.2.2	Bandirippuwa Estate	IL_1	Gravel (Boralu series)	S_4

The treatments (per palm per year) are as follows.

PRS Site

T_1 - APM (3 kg) in the entire manure circle (1.75 m) – control
T_2 - APM (3 kg) + kieserite (1 kg) in the entire manure circle (1.75 m)
T_3 - Muriate of potash (1600 g) in one half of the manure circle and kieserite (1 kg) in the other half of the manure circle, 800 g of urea and 600 g of ERP in the entire manure circle
T_4 - APM (3 kg) in the entire manure circle and kieserite (1 kg) in the entire manure circle six months later
T_5 - The manure circle is divided into two portions; 0.8 m radius circle around the palm (portion 1) and a 0.8 m wide strip encircling the portion 1 (portion 2) kieserite (1 kg) in portion 1 and APM (3 kg) in portion 2

BE Site

T_1 - APM (3 kg) in the entire manure circle (1.75 m) - control
T_2 - APM (3 kg) + kieserite (1 kg) in the entire manure circle (1.75 m)
T_3 - Muriate of potash (1600 g) in one half of the manure circle and kieserite (1 kg) in the other half of the manure circle. 800 g of Urea and 600 g of ERP in the entire manure circle
T_4 - APM (3 kg) in the entire manure circle and kieserite (1 kg) in the entire manure circle 6 months later

There were no significant differences among the different methods of muriate of potash and kieserite application, continuously for last few years in the experiment at PRS, which was terminated at the end of year 2003.

The experiment at BE has been established in 2003. The leaf and soil sampling before the application of treatment were carried out in February and May respectively. The treatments were applied in May and kieserite was not applied in November as scheduled because of dry weather.

L L W Somasiri, U G M B K Tennakoon, B S V J Perera, K J S Perera and W Gunasena

Experiment 9.0.3 : ***Determination of the effect of dolomite application on the loss of nitrogen from soils treated with urea based NPK mixtures***

This experiment was commenced in 2002 December on Boralu series soils (S_4) in Bandirippuwa Estate. The experiment consisted of eight treatments with 3 replicates on a Randomized Block Design. The treatments were applied to the soil in cement pots and placed on the manure circles of coconut palms.

The treatments were as follows.

T1	-	Control (no fertilizer)
T_2	-	Application of 5.2 g dolomite/pot and incorporate to the soil
T_3	-	Application of 4.2 g urea/pot and incorporate to the soil
T_4	-	Application of 4.2 g urea/pot and 5.2 g dolomite/pot and incorporate to the soil
T_5	-	Application of 4.2 g urea/pot and 5.2 g dolomite/pot and incorporate to the soil with a time gap (one month after urea application)
T_6	-	Application of 4.2 g urea/pot and 5.2 g dolomite/pot mixed together and incorporate to the soil
T_7	-	T_3 with mulching
T_8	-	T_6 with mulching

Fertilizers were broadcast to the soil and immediately incorporated with the soil up to 4 cm depth.

After treatment application, soil samples up to 10 cm depth were taken daily from each pot. The samples were analyzed for pH, moisture, total N, ammonia N and nitrate N at the field moist state. Temperatures of each pot were also measured daily.

The soil pH of all urea treatments increased from 4.5 to 8.25 in two days after treatment application. Thereafter it dropped sharply between 5 to 6 in 5 days and gradually came to initial level in 44 days after treatment application (Figure 1).

NH_4-N content of all urea treatments showed a sharp increase 2 days after treatment application. This increase ranged from 375 mg/kg to 860 mg/kg for all treatments except T_1 and T_2.. After 4 days NH_4-N content gradually decreased to the initial level (Figure 2).

It is clear that there was a gradual increase in NO_3-N content in all urea Treatments 2 days after treatment application (Figure3).

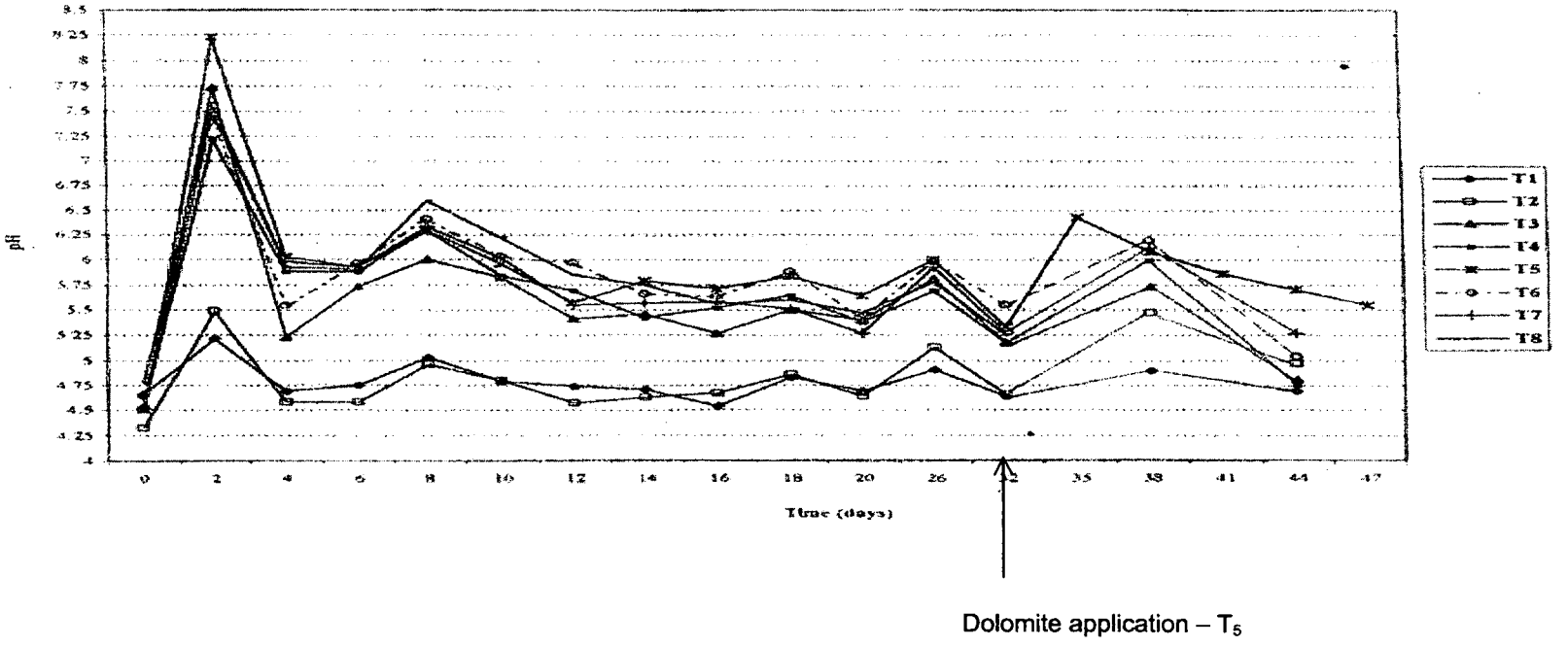


Figure 1 : *Soil pH with time after treatment application*

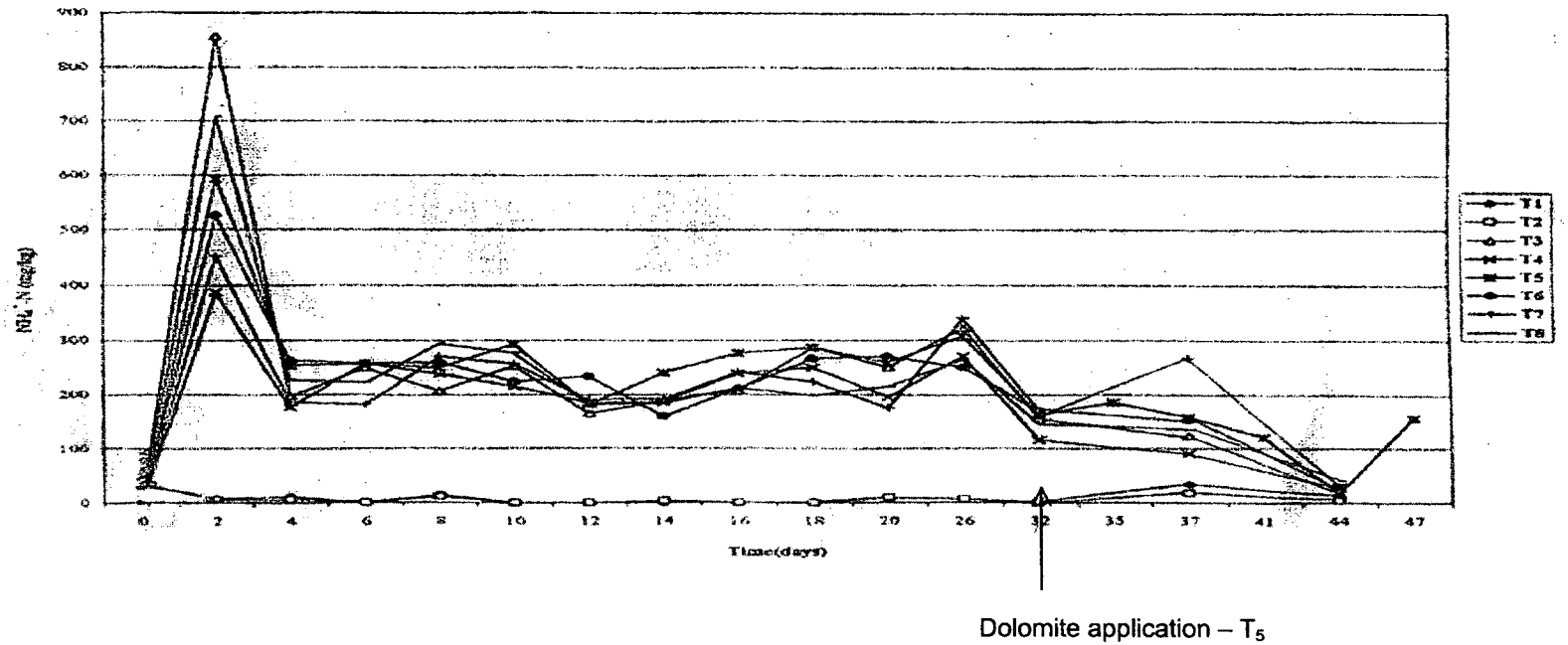


Figure 2 : *Ammonia N content with time after treatment application*

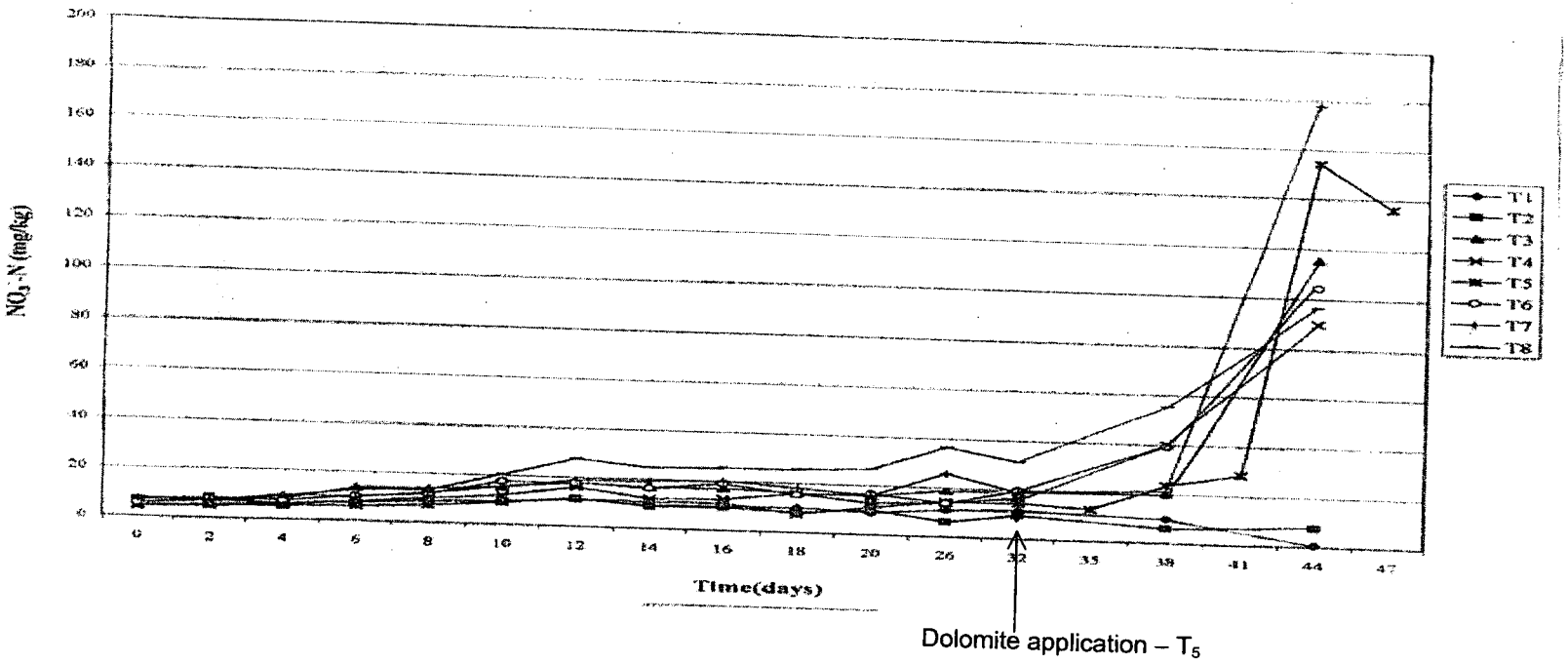


Figure 3 : *Nitrate N content with time after treatment application*

Obviously the soil pH increases significantly due to urea application to the Boralu series soil but such an increase was not observed with dolomite application alone. However, soil pH increase in dolomite treatment was observed 26 days after application. The pH increase in all urea treatments was not dependent on the presence of dolomite since there was no significant difference between T_3 (urea only), T_4 (urea + dolomite) and T_6 (urea + dolomite). The high pH level compared to the control implies the presence of $(NH_4)_2CO_3$. The decrease in pH at day 44 (Figure 1) with increase of NO_3- content (Figure 3) implies that $(NH_4)_2CO_3$ content decreases with the commencement of nitrification reactions.

The sharp increase of available NH_4^+ of the soil, 2 days after treatment application implies that $(NH_4)_2CO_3$ formation is a very rapid reaction. The increase followed by a sharp drop in available NH_4^+ with a sharp drop in pH implies a rapid drop in $(NH_4)_2CO_3$ content within 2 days (Figure 2 & 3). However, it is not very clear as to what happened to the $(NH_4)_2CO_3$ generated initially, as NO_3^- content has not increased by the day 4, either NH_4^+ had been converted to NO_2-N or Organic-N. The other possibility is the decomposition of $(NH_4)_2CO_3$ and diffusion of a considerable quantity of NH_3 to the air.

D M D I Wijebandara, N A Tennakoon, M T R D Perera and M H Danasena

Experiment 9.0.4 : *Preparation of a nutrient solution from coconut husk*

Pot Experiment

A pot experiment was established to examine the plant growth with fresh coconut husk extract use as a nutrient solution. *Panicum maximum* grass was planted in Boralu series soil (2 kg soil/pot) and following treatments were applied in a randomized Block Design with 3 replicates.

Treatments

T_1 - Control
T_2 - Husk extracts
T_3 - Nutrient solution (N, P, K, and Mg) prepared from inorganic salts.

Different physical and chemical methods were adopted to remove colour (form due to polyphenols or heavy organic materials) of the husk extracts.

The methods used were not successful. The experiment was terminated due to high expenditure involved to remove the colour of the husk extracts.

D M D I Wijebandara, L L W Somasiri and D P Panditharatne

Experiment 9.0.5 : *The effect of magnesium fertilizers on the potassium and magnesium dynamics in different coconut growing soils (2002)*

This experiment was carried out to determine the rate of change of quantity and intensity of potassium and magnesium after application of dolomite/kieserite to different coconut growing soils.

Madampe, Kalpitiya, Weliketiya and Boralu series soils were selected for the experiment. A pot experiment with Randomized Block Design with 3 replicates was established in the green house at Coconut Research Institute.

Treatments were as follows.

T_1 - Neither dolomite nor kieserite – Control
T_2 - 775 g of dolomite per 1 m^3 of soil (recommended rate of application of dolomite) - D_1
T_3 - 1550 g of dolomite per 1 m^3 of soil (recommended rate of application of dolomite x 2) – D_2
T_4 - 580 g of kieserite per 1 m^3 of soil (recommended rate of application of kieserite) – K_1
T_5 - 1160 g of kieserite per 1 m^3 of soil (recommended rate of application of kieserite x 2) – K_2
T_6 - 388 g of dolomite + 290 g of kieserite per 1 m^3 of soil (½ x recommended rate of application of dolomite + ½ x recommended rate of application of kieserite) – KD_1
T_7 - 775 g of dolomite + 580 g of kieserite per 1 m^3 of soil (recommended rate of application of dolomite + recommended rate of application of kieserite - KD_2

The equilibrium activity ratios obtained for the Madampe soil series has been published in the year 2002 Annual Report.

Due to the Research Officer in charge of this experiment has left the CRI. Therefore this pot experiment was terminated at the end of year 2003.

U G M B K Tennakoon and L L W Somasiri

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 29.

Table 29 : *Treatments of the drip irrigation experiment effects 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

Nut yield did not show significant differences among the treatments (Table 30). However, this irrigation experiment showed 71% yield increase compared to control (no irrigation) when irrigated at the rate of 40 l/day/palm at 6 days interval with 250 g of APM plus 83 g of

dolomite at monthly interval. The yield of this treatment was 28% higher than application of 40 l/day/palm at the same interval but with application of 3 kg of APM and 1 kg of dolomite annually.

Table 30 : *Nut yield of the experiment with drip irrigation*

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

These results showed that 12 split applications of APM and dolomite with irrigation (Fertigation) is more beneficial than irrigation alone. The latter treatment showed only 33% yield increase over the control (No irrigation).

L L W Somasiri, N A Tennakoon, M T R D Perera and K R E M Fernando

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

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

The objective of this experiment was to determine available nutrients in all major soils in the coconut growing areas and to attempt to establish threshold levels for each nutrient in the 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 (14th 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 last Annual Report.

It was planned to sample from Wariyapola and Maho soil series. But due to financial consisted, this sampling was not carried out in this year. The sampling will be taken in the next year.

L L W Somasiri, D M D I Wijebandara and 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 was established in 1997 on a Randomized Block Design with 3 replicates and 6 palms (45 years old) per plot.

A new site was selected at Bandirippuwa Estate in the year 2003. The experiment was established as a 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.

Eventhough nut yield were not showing any significant differences among the treatment, it was found that the nut yield of the palms receiving poultry manure increased by 36% compared to the control (no fertilizer). With cow dung, goat dung and gliricidia, the respective yield increase were 31%, 33% and 15% over the 28% control compared to the yield increase by inorganic fertilizer (APM). The results of this experiment indicated that application of organic manures such as poultry manure, goat manure and cattle manure are more beneficial than inorganic fertilizer (Table 31).

Table 31 : *Nut yield data in the RE site*

Treatment	April 1997 to march 2002 Nuts/palm	April 2002 to March 2003 Nuts/palm/yr
T_1	280	39
T_2	334	50
T_3	363	51
T_4	359	52
T_5	391	53
T_6	337	44
Level of Significance	* only in year 2002	ns
LSD (p 0.05)	20	13

N A Tennakoon, S D H Bandara and W A J Fernando

3. LABORATORY/MISCELLANEOUS STUDIES

1. Determination of available N, P, K and Mg quantity in different coconut growing soils by bioassay

The objective of this experiment was to quantify the major nutrients of widly distributed soils of the coconut growing area by bioassay techniques. A pot experiment was commenced using three different soil series (Boralu, Wariyapola and Kurunegala) with *Panicum maximum* as the indicator plant to estimate the available N, P, K and Mg quantity in major coconut growing soils.

Soils, filled into plastic pots (2 kg soil/pot) were treated with the following treatments with 3 replicates in a Completely Randomized Block Design.

T_1	-	Control (- All)	
T_2	-	-N	1 g TSP, 0.2 g KCl, 0.1 g $MgSO_4.7H_2O$/Pot
T_3	-	-P	0.16 g $(NH_4)_2SO_4$, 0.2 g KCl, 0.1 g $MgSO_4.7H_2O$/Pot
T_4	-	-K	0.16 g $(NH_4)_2SO_4$, 1 g TSP, 0.1 g $MgSO_4.7H_2O$
T_5	-	-Mg	0.16 g $(NH_4)_2SO_4$, 1 g TSP, 0.2 g KCl
T_6	-	+NPKMg (+ All)	0.16 g $(NH_4)_2SO_4$, 1 g TSP, 0.2 g KCl, 0.1 g $MgSO_4.7H_2O$

The grass was cut at monthly intervals for 3 years. The fresh and dry weight of the cuttings were recorded. The treatment application was repeated at each cutting. Monthly harvesting was stopped at the end of the 3 years after the establishment of the experiment because the vegetative growth of the grass was ceased in control treatment (T_1). Grass cuttings were chemically analyzed for N, P, K and Mg (Table 32).

Table 32 : *Percentage relative yield (RY%) in Boralu, Wariyapola and Kurunegala series in response to different treatments*

Treatment	Soil series		
	Boralu	**Wariyapola**	**Kurunegala**
- N	81.50 %	33.80 %	31.80 %
- P	30.22 %	23.55 %	4.09 %
- K	11.81 %	15.92 %	2.69 %
- Mg	-1.47 %	16.10 %	0.08 %
- NPKMg	106.17 %	76.86 %	54.6 %

The RY value of 100% or above indicates high response, 50% indicates medium response and 25% indicates low response.

Table 33 : *Nutrient removal (N, P, K and Mg) in Boralu, Wariyapola and Kurunegala series soils in response to different treatments*

Treatment	Boralu series Nutrient removal in mg/g dry weight				Wariyapola series Nutrient removal in mg/g dry weight				Kurunegala series Nutrient removal in mg/g dry weight			
	N	P	K	Mg	N	P	K	Mg	N	P	K	Mg
+ All	12.60	4.63	23.90	2.54	10.98	6.43	21.00	3.4	11.66	6.05	22.48	3.10
- N	9.34	5.63	19.37	2.76	8.56	8.14	20.27	2.78	8.02	9.26	19.74	2.92
- P	14.82	1.04	24.29	3.05	11.09	1.45	22.72	3.37	11.84	1.48	24.10	2.82
- K	14.45	5.11	8.20	1.92	10.26	6.80	13.58	3.09	14.21	5.80	11.77	3.05
- Mg	10.11	3.91	24.37	1.58	10.66	6.37	21.89	2.48	10.16	6.52	23.07	2.16
- All	10.42	1.32	12.60	2.98	9.74	1.09	17.84	2.0	7.91	1.27	10.43	2.63
Significance	***	***	**	***	ns	***	*	ns	ns	***	***	ns
LSD	1.89	1.91	5.71	0.58	-	1.06	5.59	-	-	2.80	9.11	-

The removals of P and K per unit weight of dry matter from all three soils were significantly higher in response to application of respective fertilizers.

The nutrient removal data showed that availability of all four nutrients were limiting in Boralu series by only P and K was limiting compared to other two soils. The fertility of all three soils in respect of N, P, K and Mg was comparatively low. The same in Boralu series was much lower than the other two soils.

The beneficial effect of application of N, P, K and Mg fertilizers to the above three soils, on crop improvement appeared to be in the decreasing order of Boralu series > Wariyapola series > Kurunegala series.

D M D I Wijebandara, L L W Somasiri and K P A Pathirana

2. Studies on nutrient depletion of forest soils due to coconut cultivation

The objective of this experiment is to find whether the soil is degradated when a forest converted to coconut cultivation. Samples from different soil series were taken from both forest and the adjacent coconut lands. The sampling depths were 0-10 cm, 10-20 cm and 20-30 cm.

The description of soils is given in Table 34.

Table 34 : *The description of soil samples*

Name of the forest	Location	Agro ecological zone	Soil series
Ambakelle forest	Ambakelle	IL_3	Ambakelle series
Ambakelle forest	Ambakelle	IL_3	Welipelessa series
Kankaniya Mukalana	Kuliyapitiya	IL_1	Andigama series
Horakelle forest	Labugammana	IL_1	Kuliyapitiya series
Horakelle forest	Mohottawa	IL_1	Kiriwana series
Dickelle forest	Galayaya	IL_3	Boralu series
Ahalagollayaya forest	Hawanatanna	IM_3	Melsiripura series
Badagamuwa forest	Badagamuwa	IL_1	Kuliyapitiya series
Weuda forest	Galdgedara	IM_3	Melsiripura series
Sawarangala forest	Sawarangala	IM_3	Melsiripura series

The available K, Mg, Ca and Na contents of the soil series investigated are given in Figures 4, 5, 6 and 7 respectively.

In Ambakelle, Andigama and Kuliyapitiya (Horakelle Forest) series soils, there was an increase of K content in the soils under forest cover compared to the coconut cultivated area. But in case of Welipelessa and Kiriwana series soils, K contents were low in area under forest.

The Mg content of all soil series was higher under forest cover than under coconut.

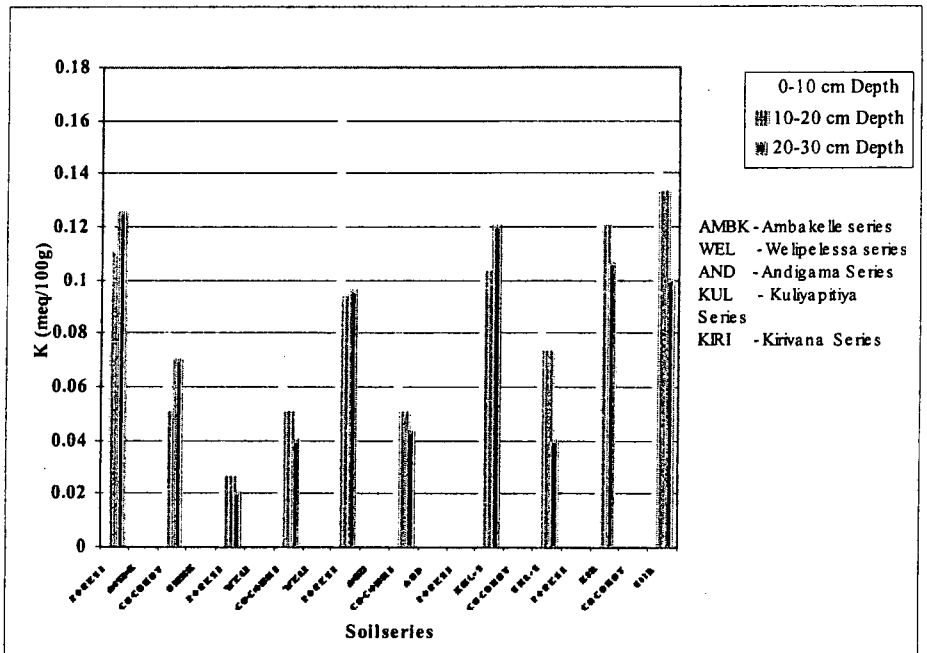


FIGURE 4: Available K content in different soil series under forest cover and coconut

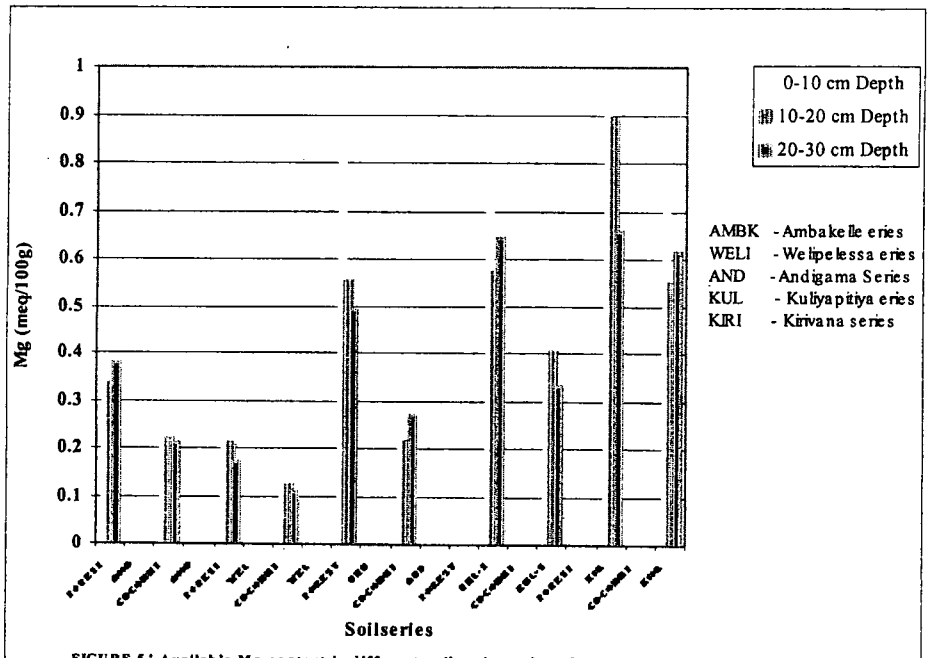


FIGURE 5: Available Mg content in different soil series under forest cover and coconut

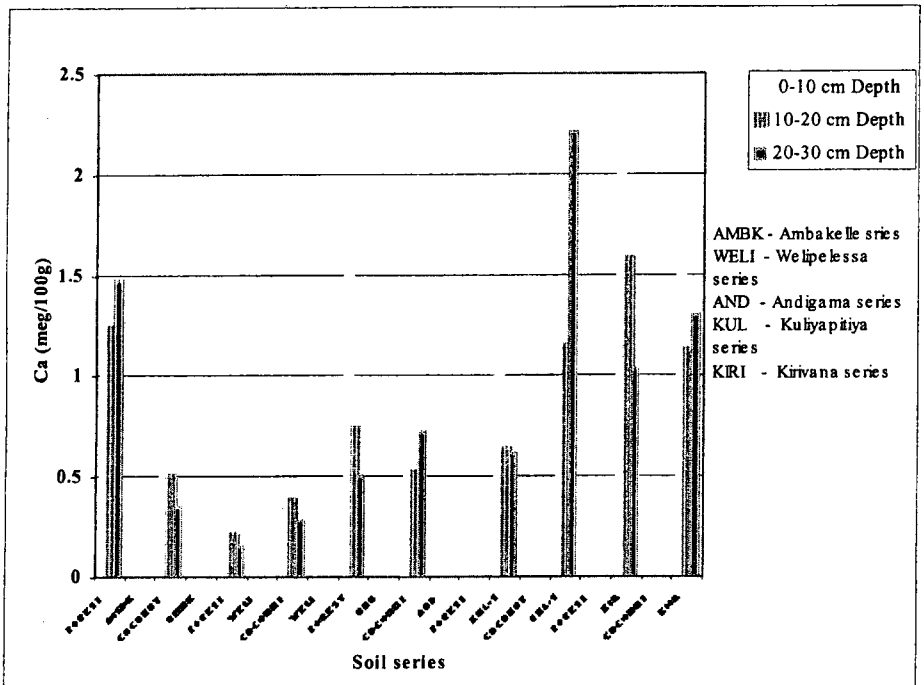


FIGURE 6: Available Ca content in different soil series under forest cover and coconut

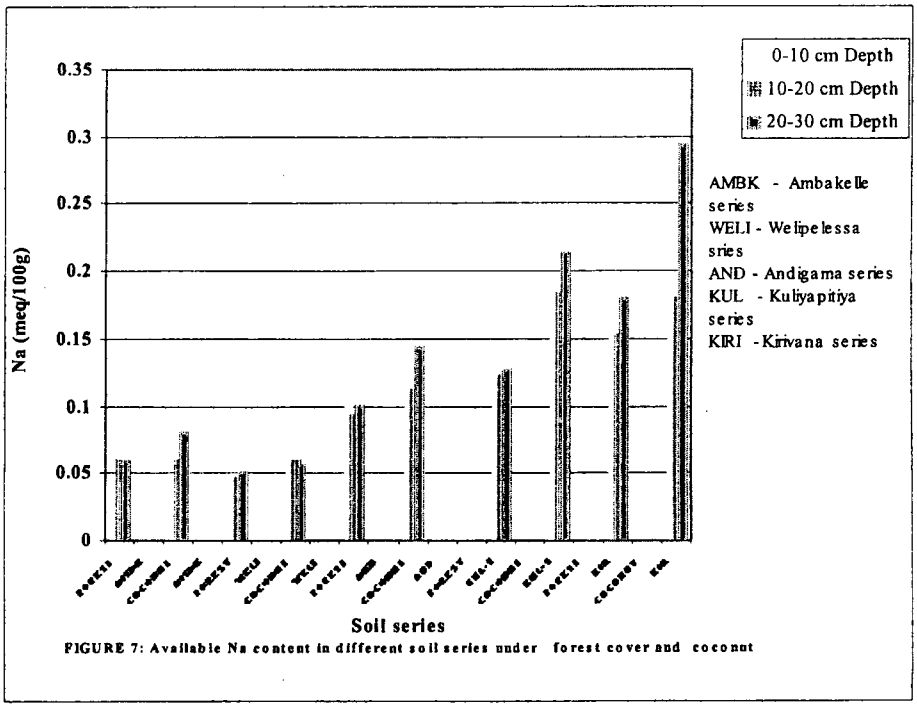


FIGURE 7: Available Na content in different soil series under forest cover and coconut

In case of Ambakelle, Andigama and Kiriwana series soils, Ca content was higher in forest cover than coconut cultivated area. But in the Welipelessa and Kuliyapitiya series soils, Ca contents were low in area under forest cover. The Na content in Ambakelle and Welipelessa series soils was same for both area under forest cover and area under coconut. But the Na content in Andigama, Kuliyapitiya and Kiriwana soil series was higher in the coconut cultivated area than area under forest.

D M D I Wijebandara and L L W Somasiri

4. SERVICE FUNCTIONS

Differential Fertilizer Recommendation	172 growers
Land suitability tests for coconut cultivation/surveys	24 growers
Inorganic fertilizer analysis	179 samples
Organic fertilizer analysis	49 samples
Analysis of coir pith samples	240 samples
Soil Analysis	2065 samples
Leaf Analysis	1988 samples
Participation in training programmes	12

5. EXTENSION ACTIVITIES

Dr. N.A. Tennakoon participated as a resource person in training programmes conducted by Coconut Development Training Centre, Coconut Cultivation Board, Lunuwila.

Dr. N.A. Tennakoon participated as a resource person in 4 training programmes on Application of Eppawela Rock Phosphate to coconut conducted by Phosphate Lanka (Pvt) Ltd, Colombo.

Dr. N.A. Tennakoon participated as a resource person in training programmes conducted by NIPM.

Dr. N.A. Tennakoon and D.M.D.I. Wijebandara, participated as resource persons in one day programme on Fertilizer Usage held in Coconut Research Institute.

6. ACKNOWLEDGEMENTS

I sincerely thank the Acting Deputy Director (Research) Dr. L.L.W. Somasiri for his commitment and the Head and the staff of the Biometry Division for the assistance in designing field experiments, data recording and statistical analysis.

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 with the objective of developing an integrated management programme. The research was mainly focused on biological and chemical control methods.

Development of a laboratory rearing technology for the predatory mite, *Neoseiulus* aff. *paspalivorus* was continued with the view to augment them in coconut mite infested fields. The mite, *Tyrophagus putriscentiae* was found to be a superior prey of *N. paspalivorus* to that of *Tetranychus urticae*. A preliminary study by releasing predatory mites on to bagged infested bunches showed that about 70% reduction of coconut mite density could be obtained by using predatory mites. The collaborative project with CABI Bioscience, 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 four Districts indicated that *H. thompsonii* was present in all the areas, but the incidence on nuts was less than 10%. Preliminary field studies indicated that over 80% mortality of coconut mites occurred 1-2 months after spraying the fungus on to infested nuts.

Repeated application of carbosulfan 20% (Marshal SC 20) at monthly intervals by spraying and root feeding reduced the percentage infestation in the developing bunches by 70%. Studies indicated that application of 30% used engine oil and surfactant mixture on the perianth of nuts gives nearly 100% mortality of coconut mites. After the treatment the damage on affected nuts discontinued while unaffected nuts remained free from damage throughout their development.

Studies on the diurnal pattern of migration of coconut mite showed that the highest number of mites left the perianth at 4.00 a.m. in the morning. Fluctuation of the populations of coconut mite and predatory mites in three different areas showed a trend similar to that of previous years. Development of the software for the image processing to count coconut mites was continued. A survey to determine the crop loss due to coconut mite and a study on the effect of nutrition of the palm on the severity of the damage were initiated.

Artificial inoculation of healthy palms consistently yielded the fungus *Ceratocystis paradoxa* confirming that it is the major fungus responsible for the leaf rot disease. The fungicides "contaf" and "folicur" were effective in suppressing mycelium growth and conidia production of *C. paradoxa*.

The trend in the population fluctuation pattern of the parasitic nematode, *Radopholus similis* infesting coconut roots was similar to that of previous years. A preliminary study indicted a difference in components of the cell sap between the healthy and Leaf scorch decline affected palms. The Division collaborated on studies on Rapid decline syndrome.

A Research Officer of the Department of Agriculture released by the Department from December, 2002 continued to work on the collaborative project with CABI Bioscience to develop strategies to use *Hirsutella* fungus to manage coconut mite. An acarologist of University of Sao Paulo, Brazil visited the Division for one month in July, 2003 to advice on the research programme on using predatory mites for the management of coconut mite. The Council for Agricultural Research Policy to develop biological and chemical methods to manage coconut mite awarded a three-year research grant of Rs.1.1 million.

The Division continued to serve the coconut growers by providing advice in managing pests and diseases and sale of pheromone vials and monocrotophos for the management of red weevil. An outbreak of coconut caterpillar was reported from nearly 35,000 palms in a plantation in Polonnaruwa area, which was the largest in the recent years. Laboratory-bred parasitoids were continued to release to manage the outbreaks.

2. RESEARCH PROJECTS

PROJECT 26 : IMPROVEMENT OF INTEGRATED MANAGEMENT PROGRAMME FOR RED WEEVIL (1998)

Experiment 26.1 : Development of an electronic device for the detection of red weevil infested palms (1998)

The device that was developed and field-tested in the previous years needed improvement in two aspects viz. use of an alarm or visual display to indicate the presence of larvae and a convenient device to mount the sensor. Sufficient progress was not made due to the shortage of supporting staff of the collaborator at the University of Moratuwa. Study is being continued.

P. Fernando, K.F.G. Perera, W.W.F.N. Fernando & D.P.N. Nanayakkara
(University of Moratuwa)

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 paspalivorus (1999)*

The experiment conducted to determine the seasonal population fluctuation patterns of the coconut mite and the predatory mite, *Neoseiulus paspalivorus* was continued in 6, 7 and 4 sites in Kalpitiya, Madurankuliya and Wanathavillu respectively. One young nut from each of five palms in each site was sampled at monthly intervals and the number of coconut mites and predatory mites on each nut was recorded. As in the previous years, populations of both species of mites fluctuated over time in all experimental sites. In Kalpitiya, *A. guerreronis* reached its peak population level in July-August, August and May-June in 2000, 2001 and 2002 respectively (Fig. 1). In Wanathavillu its peak population levels were in August-September, July-August and October in 2000, 2001 and 2002 respectively (Fig. 2). However, another peak was observed in April, 2000 after a relatively dry period. In Madurankuliya peak populations were observed in June-September, June-September and May- September in 2000, 2001 and 2002 respectively. Pest population was very high in January 2000 after relatively low rainfall in December 1999 (Fig. 3). In general, it appears that the pest population remains high either during dry periods or soon after dry months. *N. paspalivorus* did not show a specific fluctuation pattern in any site. Distribution of predators on nuts has increased over the three years in Madurankuliya and Wanathavillu while at Kalpitiya it is more or less unchanged (Table 1). It appears that predator density has also increased in the areas studied (Table 1).

The 3-year study was completed. A new study was initiated to determine the population patterns of pest and predators including damage assessments in Puttalam, Kurunegala and Anuradhapura districts.

N. S. Aratchige, K. A. S. Chandrasiri & P. Manoj

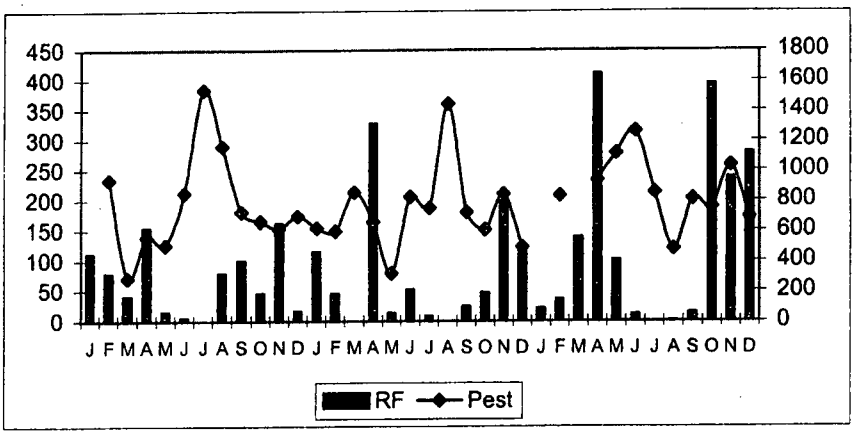


Fig.1. : *Relationship between mean number of A. guerreronis and monthly rainfall in Kalpitiya*

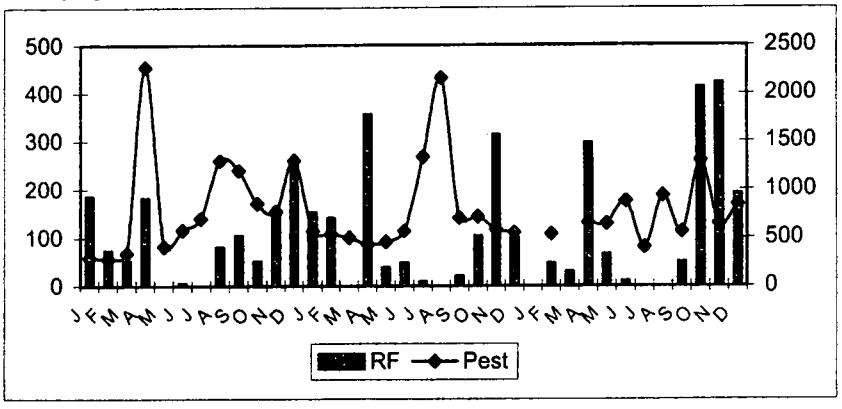


Fig.2. : *Relationship between mean number of A. guerreronis and monthly rainfall in Wanathavillu*

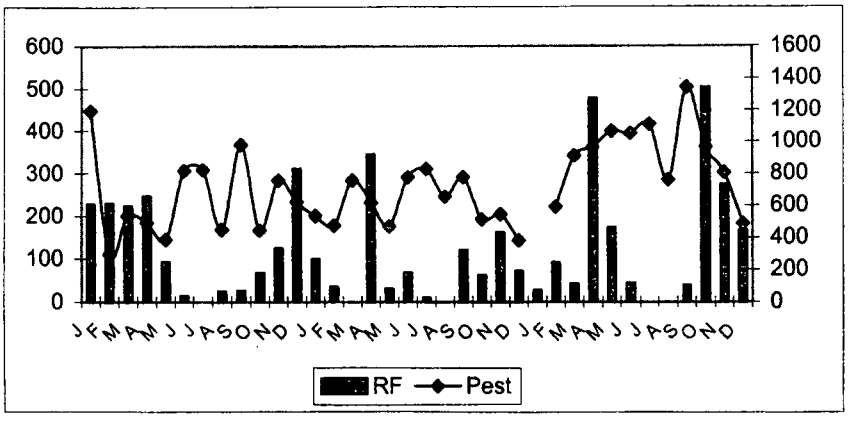


Fig.3. : *Relationship between mean number of A. guerreronis and monthly rainfall in Madurankuliya*

Table 1 : *Density (mean number per nut) and distribution (mean number of nuts with mites) of N. paspalivorus in the three sites, Kalpitiya, Madurankuliya and Wanathawillu*

Site	Density			Distribution		
	2000	2001	2002	2000	2001	2002
Kalpitiya	87.1	66.7	93.4	13.4	11.0	15.0
Madurankuliya	56.5	45.2	79.1	9.5	10.7	16.0
Wanathavillu	24.7	31.9	42.2	4.7	5.6	7.0

Experiment 27. 29 : Determination of the life cycle of coconut mite (2002)

Duration and size of each stage of the life history was determined. The results of the study are summarized in Table 2. The first larval stage was relatively a slow moving stage. During the resting stages the body became pointed and looked more transparent compared with the active stages.

Table 2 : Duration and size of each stage of the life history of *Aceria guerreronis*

Stage of the cycle	Duration (Mean no of days)	Mean size (µm)
Egg	1.9	34.8
Larva	1.9	82.5
1st inactive stage (Nymphochrysalis)	1.4	115.6
Nymph	2.5	157.1
2nd inactive stage (Imagochrysalis)	1.0	168.7
Adult		195.0

S. R. Sarathchandra, I. R. Wickramananda & D. A. Appuhamy

Experiment 27.30 : *Development of a digital image processing system to count coconut mites (2002)*

Development of the software was continued. Digital images obtained at several times were used in the process. The compatibility of the software to Microsoft and improvements to the images will be carried out in proceeding years.

I. R. Wickramananda & M. Alahakoon (University of Peradeniya)

Experiment 27.31 : *Determination of the peak time of migration of coconut mite in the field (2003)*

Previous laboratory studies elsewhere have indicated that the coconut mite comes out of the perianth early in the morning and reaches a peak at 4.00 am. This was verified in the field. Nut samples from the 4th bunch were collected at 2 h interval from 6 pm to 10.00 am. 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 coming out of the perianth reached its peak around 4.00 a.m. (Fig. 4), which confirmed the laboratory findings.

A. D. N. T. Kumara, I. R. Wickramananda & D. A. Appuhamy

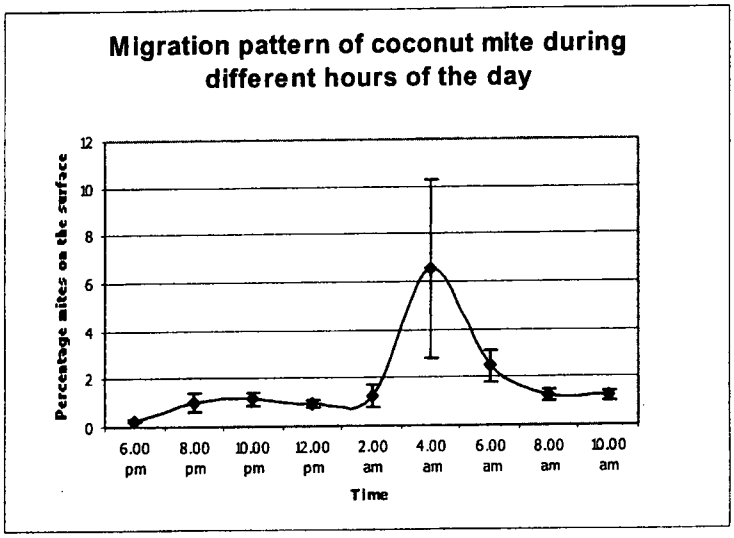


Fig 4 : *Percentage of A. guerreronis coming out of the perianth for migration at different hours of the day*

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

A survey was initiated in Puttalam District to study the crop loss at harvest due to coconut mite damage. Thirty sampling points were randomly selected and the harvest records with different categories and parameters such as nut number, fresh nut weight and husked nut weight were considered. Data was collected monthly and later the study was modified and combined with Agronomy and Biometry Divisions to do a detailed survey representing four districts and more parameters. Data collected so far indicated that the overall nut crop loss due to mite attack was about 5.5% in the Puttalam District. Study is being continued.

I. R. Wickramananda & T. Bandara

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 is being carred out to determine the optimum fertilizer mixture for coconut. 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)
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. Levels of major and some micronutrients were not significantly different between the three treatments (Tables 3 & 4). Study is in progress

Table 3 : Levels of macro nutrients in the 14th frond of different treatments

Fertilizer level	N %	P%	K%	Mg%
Control	2.07	0.13	0.95	0.32
APM	2.16	0.14	1.03	0.28
Double APM	2.22	0.14	1.13	0.27
Significance	NS	NS	NS	NS
Sufficiency range	1.9-2.1	0.11-0.13	1.2-1.5	0.25-0.35

Table 4 : Levels of macro nutrients in the 14th frond of different treatments

Fertilizer level	Ca %	Na %	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
Control	0.38	0.18	112.5	194	6.3	34.7
APM	0.37	0.22	127.5	194	6.4	30.1
Double APM	0.38	0.13	128.3	232	5.9	28.6
Significance	NS	*	NS	NS	NS	NS
Sufficiency range	0.35-0.5	0.4	40-	60-	5-	30-

I. R. Wickramananda & T. Bandara

Experiment 27.34 : *Fecundity of Neoseiulus paspalivorus fed on coconut mite (2003)*

The study was conducted to determine the lifetime fecundity of *N. paspalivorus* females when fed on coconut mite. Twenty females were individually introduced on to arenas at the deutonymph stage along with a male. They were provided with abundance of coconut mites for feeding. The number of ovipositions was recorded daily until the death of the female. The females deposited an average of 32.0±2.5 eggs (1.7 eggs/day) during its lifetime.

P. Fernando & C. Wawegedara

Experiment 27.35 : *Sex ratio of Neoseiulus paspalivorus (2003)*

Each of five *N. paspalivorus* eggs was kept in 10 arenas and the hatched out nymphs were provided with abundance of coconut mites for feeding. At the deutonymph stage the number of males and females were recorded. The female: male ratio was 3.5:1.

P. Fernando & M. Kumari

Experiment 27.19 : *Comparison of Tetranychus cinnabarinus and other food sources on development and reproduction of N. paspalivorus (2001)*

A preliminary study in the previous year showed that *N. paspalivorus* developed satisfactorily on *Tetranychus urticae* and *Typha* pollen. Therefore, the study was conducted to confirm these observations and to determine the development period and life-time fecundity of the predatory mite on other food sources with a view to identify a suitable food source for mass breeding of the predatory mite. Two separate experiments were conducted to determine the development period and fecundity.

The prey mite that was thought to be *T. urticae* was later confirmed as *Tetranychus cinnabarinus*. Six comparisons of food sources or their combinations viz. coconut mite, *T. cinnabarinus*, *T. cinnabarinus*+coconut pollen, *T. cinnabarinus*+*Typha* pollen, *Typha* pollen and coconut mite+ coconut pollen were made for both except, Coconut mite+ coconut pollen combination for the experiment on development. To determine the development period, 10 eggs were individually placed in arenas for each treatment and provided with abundance of the respective food source. The durations of different development stages were recorded up to the adult stage. To determine the fecundity the same food sources were tested. Each of 10 female deutonymphs was individually placed in arenas for each treatment, provided with abundance of the respective food source to record number of ovipositions until the death of the females. The development period and fecundity of *N. paspalivorus* varied significantly ($P<0.0001$) among the different food sources fed on. The shortest development period, pre-oviposition period and the highest ovipositions were recorded on coconut mite (Table 5).

Table 5 : *Comparison of different food sources on development, pre oviposition period and fecundity of N. paspalivorus*

Food source	Development (days±S.E.)	Pre-ovipositional period (days±S.E.)	Mean number of eggs ± S.E
Coconut mite	5.6±0.4	3.2±0.2	22.4±1.7
T. cinnabarinus	8.2±0.6	6.4±0.3	5.1±0.5
T.cinnabarinus+coconut pollen	6.3±0.7	5.2±0.6	6.4±0.6
T.cinnabarinus+Typha pollen	7.4±0.5	7.1±0.4	5.6±0.5
Typha pollen	11.3±0.6	0	0
Coconut mite+ coconut pollen	-	3.4±0.2	18.8±1.7

P. Fernando, C. H. Hapuarachchi & R. Silva

Although they developed well on *T. cinnabarinus* their ovipositions were very low on this food source and its combinations with pollen. Therefore, these sources are not suitable for breeding the predator.

Experiment 27.36 : *Rate of consumption of T. cinnabarinus eggs by N. paspalivorus (2003)*

To determine the requirement of the number of eggs of the prey for breeding of the predator 15 newly hatched larvae of *N. paspalivorus* were placed on individual arenas and 30 *T. cinnabarinus* eggs were provided daily. The number of eggs consumed by the different stages of the predator was recorded daily. An average of 5.7, 7.5 and 9.7 eggs were consumed by larva, protonymph and deutonymph stages respectively. The adults fed on 4.8 eggs per day.

P. Fernando & M. Kumari

Experiment 27.37 : Development and fecundity of *N. paspalivorus* on a new prey, *Tyrophagus putriscentiae* (2003)

Consequent to preliminary observations that *N. paspalivorus* feeds on newly hatched nymphs of *Tyrophagus putriscentiae* found occasionally on infested nuts, the study was conducted to determine the suitability of this host as an alternate prey to mass breed the predator. Twenty eggs of *N. paspalivorus* were placed individually on arenas established with abundance of *T. putriscentiae* and the developmental period of the predator was recorded. The predator developed to the adult stage successfully on the host with a mean time of 9.4 days. To determine the lifetime fecundity 15 mated female duetonymphs were individually placed on arenas with the host and the number of eggs laid by each female until their death was recorded. *N. paspalivorus* laid an average of 26.4±2.2 eggs and lived an average of 66.2±2.2 days. The results suggest that *T. putriscentiae* is a suitable host for mass breeding of the predator.

P. Fernando, M. Kumari & D. Appuhamy

Experiment 27.38 : *Development and fecundity of T. putriscentiae on Typha pollen (2003)*

Rearing of *T. putriscentiae* in the laboratory using *Typha* pollen was determined. Forty eggs of *T. putriscentiae* were placed individually on arenas with sufficient *Typha* pollen and recorded the development period of the females up to the commencement of ovipositions.

The females were raised in the arenas until their death and the number of ovipositions during that time was recorded. *T. putriscentiae* took a mean of 7.3±0.4 days (n=22) to commence oviposition. An average of 127.1±12.9 eggs (n=20) were laid during the lifetime with an average of 6.0±0.8 eggs daily.

P. Fernando & M. Kumari

Experiment 27.39 : *Studies on breeding of coconut mite and the predator on embryo-cultured seedlings (2003)*

Preliminary studies in the previous years have shown that coconut mites could be bred on tender bud leaves of coconut for a limited period of time. This method was tested in large number of tissues and found that a 11-fold increase in the coconut mite population could be obtained on the tissues in 10 days. However, the number varied largely according to the state of the tissue and was frequently contaminated by fungi. Therefore, with a view to breed coconut mites in a large scale in the laboratory suitability of using embryo cultured plants were tested. The preliminary study showed that an average of 25,000 mites per 2-5 month old embryo culture seedling could be obtained in one month by introduction of 75 coconut mites. Also, it showed that predatory mites too could be successfully bred on the coconut mites on the same seedlings. A designed experiment was initiated to quantify the coconut mites and predatory mites that could be bred on seedlings of different ages.

P. Fernando, R. Silva & K. Rathnayake

Experiment 27.40 : *Effect of releasing N. paspalivorus on coconut mite population (2002)*

Three bunches of 3 infested trees were enclosed in muslin cloth and released about 500 predators in each while another set of 3 bagged bunches were left without releasing predators. Bags were removed after three days and the pest and predator populations on two nuts of each bunch were monitored at different intervals. Results showed that the coconut mite density reduced by about 70% just after the release and kept same until end of sampling (Fig. 5). On non-released bunches the coconut mite density did not reduce until end of sampling. This preliminary study showed that *N. paspalivorus* could reduce the pest population when augmented.

P. Fernando, S. Chandrasiri, G. Perera, C. Wawegedara, R. Silva & R. Caldera

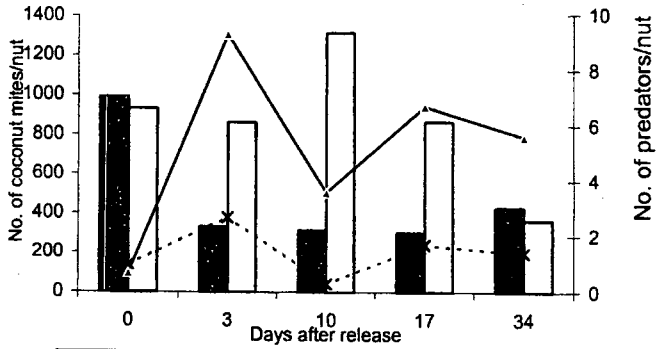


Fig. 5 : *Coconut mite and predatory mite densities before and after release of predatory mites on infested trees*

Experiment 27.41 : *Survey for alternate prey species of N. paspalivorus in the field (2003)*

Up to date *N. paspalivorus* has been reported to prey only on *Aceria guerreronis* in the field. With a view to understand its relationship with other natural host species and to determine its predatory type a survey was conducted to collect different plant species in the vicinity of coconut mite infested fields. The specimens were collected and Professor Moraes of the University of Sao Paulo, Brazil commenced identifications.

P. Fernando, C. Wawegedara, M. Kumari, C.H. Hapuarachchi, R. Silva, D. Appuhamy & G.J de Moraes (University of Sao Paulo, Brazil)

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

A survey was initiated to collect infested coconut samples from different infested areas of the country to determine the natural incidence of *H. thompsonii*. The survey was carried out in Puttalum, Kurunegala, Anuradhapura and Gampaha Districts. No incidence was reported from Anuradhapura District while in other districts the incidence was less than 10% except, in Maho CDO range, which had an incidence of 35%. Study is in progress.

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

Experiment 27.43 : *Proof of pathogenecity of Hirsutella thompsoni on coconut mite (2003)*

The local strain of *H. thompsonii* was isolated and the methodology of isolation was improved. A study was conducted to prove that *H. thompsonii* isolated from dead coconut mites on the infested coconuts in the field is pathogenic to coconut mite. A disease free coconut mite colony was obtained by raising the mites from the egg stage in the laboratory. The fungus was cultured on malt extract agar and pieces of conidia bearing mycelial clots were placed on surface sterilized, tender bud leaf tissues of coconut. The tissues were incubated to allow the fungus to grow on the leaf tissue. After 5 days leaf tissues with newly hatched coconut mites were kept in touch with the inoculated leaf tissues until the coconut mites were moved to the inoculated tissue. Another set of leaf tissues, which were not inoculated with the fungus, was placed with coconut mites as the control. One week after, the dead mites in the treated set were incubated at 100% RH and 27^{0}C and confirmed infection by observing the mycelium of the fungus inside the body of the dead mites with the aid of a phase contrast microscope (x400). All mites in the treatment were dead due to the fungus proving the pathogenecity of local strain of *H. thompsonii* on coconut mites. None of the mites in the control were dead.

M. A. K. Wijesinghe (Department of Agriculture) & I. Rubasinghe

Experiment 27.44 : *Evaluation of efficacy of local strain of H. thompsonii on coconut mite (2003)*

The efficacy of the local strain of *H. thompsonii* on coconut mite was determined in a laboratory study. Twelve mite-infested young coconuts were selected, surface sterilized with 70% ethanol and bracts were removed carefully with the help of a sterilized scalpel. Small clots of fungus mycelium of similar size were placed on mite-infested areas of the nut surface. The bracts were replaced and tightened with rubber bands and kept in room conditions for 5 days. Similarly pieces of sterilized papers, which were of similar size of mycelia clots used for inoculation, were placed on the surface of another set of 12 nuts. A significantly higher percentage of mites were dead (78.7%) in the treated nuts compared to

30.7% of untreated nuts indicating that the local isolate is effective in causing mortality of coconut mite.

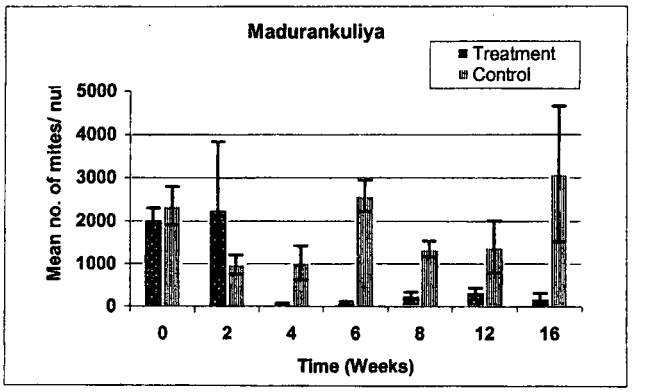
M.A.K. Wijesinghe (Department of Agriculture) & I. Rubasinghe

Experiment 27.45 : *Evaluation of the efficacy of local strain of H. thompsonii on coconut mite in the field (2002)*

Efficacy of the local isolate of *H. thompsonii* was tested in three locations at Madurankuliya, Mundel and Mampuri. The fungus was mass cultured in submerged medium (Nutrient enrich medium) and blended with water to obtain a suspension of $5x10^5$ CFU/l in concentration. The suspension was sprayed onto young infested bunches of 10, 6 and 5 palms at Madurankuliya, Mundel and Mampuri respectively at the rate of 2 l/palm using a knapsack sprayer. Spraying was done at evening to avoid possible harmful effects from sunlight. Five palms in each location was sprayed with water as the control. Spraying was done twice in each location. At Mundel and Mandurankuliya second spraying was done 2 weeks after the first where as at Mampuri it was done two months after the first spraying. Total numbers of mites in one four-month old nut of each palm were recorded prior to treatment and two weekly intervals during first two weeks and monthly thereafter.

The results showed that *H. thompsonii* was effective in reducing coconut mite populations up to about 2 months after spraying (Fig. 6). Thereafter, the populations tend to increase indicating poor establishment of fungus in the field. This may be attributed to the strain used, insufficient quantities of fungal inoculum used, inadequate frequency and interval of spraying etc. These factors have to be determined in further studies.

M. A. K. Wijesinghe (Department of Agriculture), I. Rubasinghe, A. D. N. T Kumara & R. Caldera



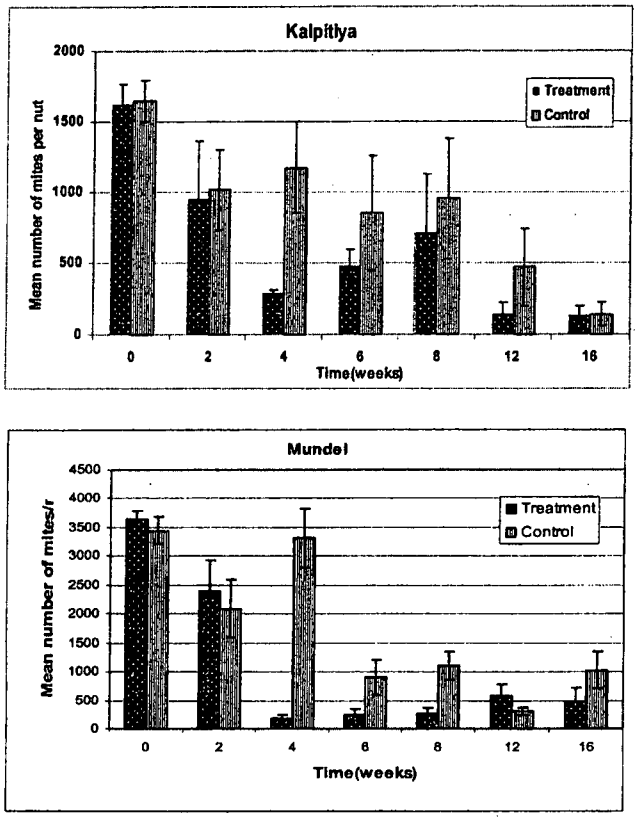


Fig. 6 : Mean numbers of coconut mites per nut on treated and untreated palms at different intervals after spraying of *H. thompsonii*

Experiment 27.25 : *Re-evaluation of sulphur against coconut mite under field conditions (2002)*

Six spraying rounds were completed. However, clear reduction in mite population or damage severity were not found in treated palms. As the co-operation extended by the owner was not encouraging and the results were not promising the experiment was discontinued.

I. R. Wickramananda, K. F. G.Perera, C. Hapuarachchi & N. G. Premasiri

Experiment 27.26 : *Evaluation of Neemarin 1500 and safers fatty acid salt against coconut mite (2002)*

Preliminary observations made in the previous year did not indicate a satisfactory effect of both treatments on the mortality of mites of treated nuts. However, to verify the effect of Neemarin, application was repeated. A modified knapsack sprayer was used for spraying the chemical at the rate of 2-3 l per palm. Observations made over a period of one month showed only up to 30% mortality of mites, which was not sufficient. The study was terminated.

I. R. Wickramananda & T. Bandara

Experiment 27.27 : *Evaluation of marshal 20% and chlorpyrifos 40% against coconut mite (2002)*

In the ongoing chemical screening trials, highly infested scattered palms are usually selected and sprayed to evaluate the efficacy of chemicals against coconut mite in the field. In this experiment a modified method was followed. Three blocks of infested palms each comprising approximately 60 palms were selected. Each of two blocks was sprayed with marshal 20% (4ml/l) and chlorpyrifos (2ml/l) respectively at the rate of 1.5 l per palm. Third block was left untreated. Harvested nuts were collected in all three blocks and the nuts were categorized according to the severity of damage at each harvest. Results of the experiment did not show a notable effect of spraying either of the chemicals on nut yield. The experiment was concluded.

Table 6 : *Mean number of nuts/ac/pick for different treatments*

Treatment	Healthy	Surface damaged	Deformed	Rejected	Total
Marshal	3.50	141	30.50	4.00	179.00
Chlorpyrifos	9.67	125	13.67	2.00	150.33
Control	31.67	113	17.67	4.33	166.67

I. R. Wickramananda, N. S. Aratchige, K. A. S.Chandrasiri, W. W. N. Fernando & R. Wijetunga

Experiment 27.46 : *Effect of application of Econeem Plus (Azadirachtin 1%) on coconut mite (2003)*

A preliminary study was conducted at Madurankuliya to determine the effect of application of Econeem Plus, a botanical containing 1% azadirachtin, which has been recommended in India. The chemical was applied by three application methods i.e. trunk injection (10ml/palm), root feeding (10 ml/palm) and spraying (4ml/lit). Mortality of coconut mites was assessed. Results did not show a marked effect on the mortality of mites (Fig. 7). India has recommended this chemical only to be applied by trunk injection. Therefore, a repetition of treatments with trunk injection continued. The experiment is in progress.

I. R. Wickramananda & D. A. Appuhamy

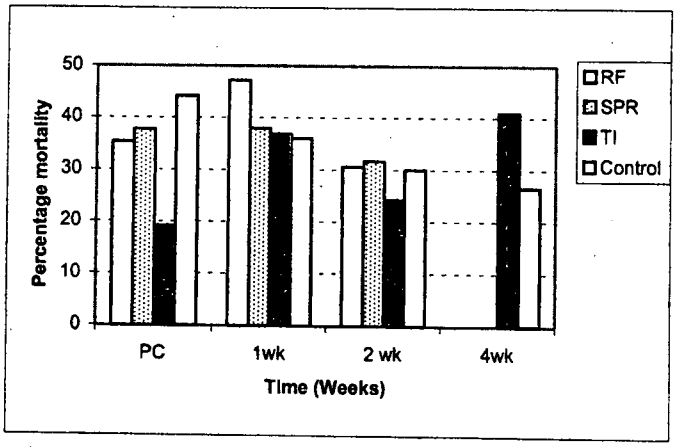


Fig. 7 : Percentage mortality of coconut mites in treatments of Econeem Plus by root feeding (RF), Spraying (SPR) and trunk injection (TI).

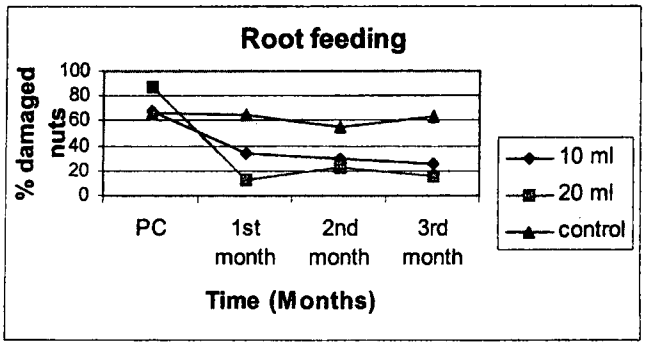
Experiment 27.47 : *Evaluation of Marshal 20 SC against coconut mite in the field (2003)*

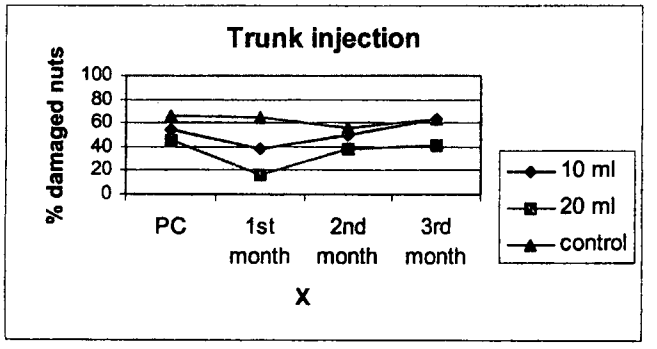
Marshal 20 SC (Carbosulfan 20%) is a new formulation, which is systemic in action. The efficacy of this chemical was evaluated using three application methods i.e. root feeding (10 & 20 ml /palm), trunk injection (10 & 20 ml/palm) and crown spraying (2 & 4 ml/lit). Preliminary results indicated that application of Marshal SC considerably reduced both mite populations (Fig. 8) and new damage in the emerging new bunches (Fig. 9) over time. As the results of this preliminary trial was encouraging, the chemical will be tested in large blocks to verify the efficacy in order to make a recommendation.

A. D. N. T. Kumara, I. R. Wickramananda & D. A. Appuhamy

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

A preliminary observation showed that application of used (burnt) engine oil mixed with water and a surfactant on to the perianth of coconut mite infested nuts gives a very high mortality of mites. Therefore, a study was conducted at Udappuwa to test different concentrations, 40%, 30% and 20% of engine oil and confirm its effectiveness in reducing coconut mite population. Nuts of 2-6 month old infested bunches in each of ten palms were applied with each concentration of oil while the same number of untreated palms were used as the control. One nut from 3-5 month old bunch of these palms was picked at different intervals and number of live mites and predators were assessed.





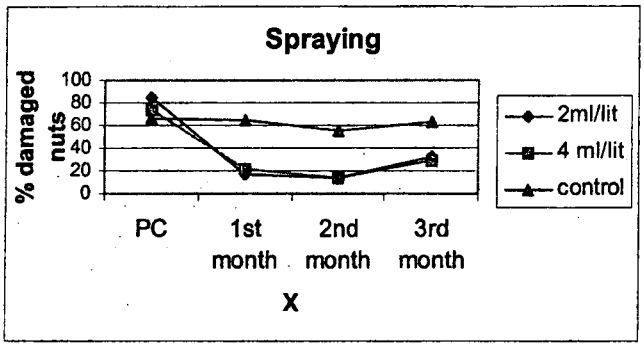
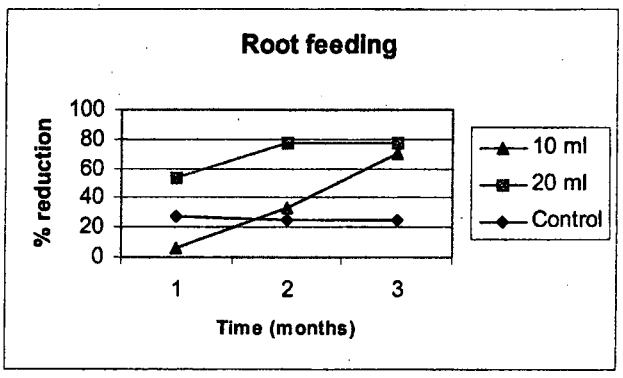
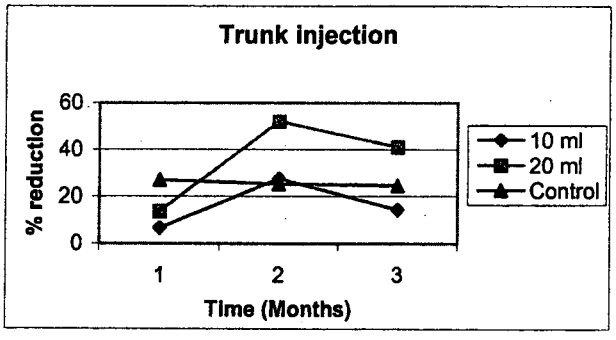


Fig 8 : Change in the percentage damage in the 4th bunch with time in different treatments





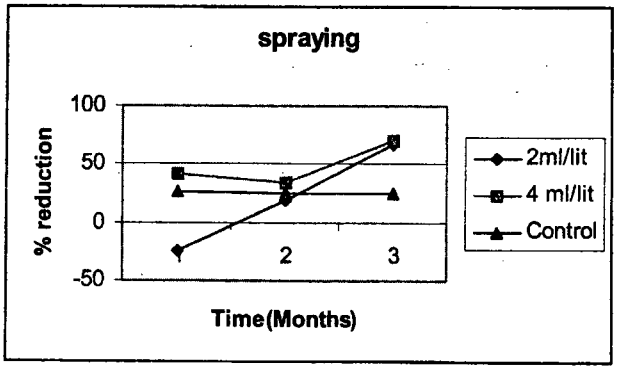


Fig 9 : Percentage reduction in population with respect to initial population in different treatments

Also, the total number of fallen nuts from each palm and percentage of damaged nuts in treated and newly developing nuts were recorded. All concentrations of used oil gave very high mortality of mites and remained so until the last sampling (Table 7). Using 30% concentration could be recommended in further studies as few mites was present in 20% treatment. The damage was discontinued on nuts and development of fresh damage on those bunches was very little compared to the untreated palms (Table 8). However, the symptoms of damage developed on newly developing, untreated bunches although the number of damage nuts was less in treated palms than on untreated palms (Table 8). The total number of fallen nuts in all the treated bunches was 10, 7 and 9 in 40%, 30% and 20% treatments respectively compared to 33 in the control palms. Also no adverse effect on nuts was observed. However, the predatory mite population was drastically affected by the treatment (Table 9).

The study was repeated in a site at Anuradhapura with 30% used engine oil solution. Two to six month old infested bunches of twenty palms were applied with the oil solution while another 10 infested palms were used as the control. One nut from 3-5 month old bunch of these palms was picked at different intervals and number of live mites and predators were assessed. Also, the total number of fallen nuts from each palm and percentage of damaged nuts in treated and newly developing nuts were recorded. Results confirm the above findings (Tables 10 & 11). The percentages of fallen nuts were 21.9, 40.4, 6.0 and 7.2 in 4-month old treated, 4-month old untreated, 6-month old treated and 6-month old untreated bunches respectively confirming that nut fall due to treatment does not occur.

Studies were initiated in each of one-acre blocks at 4 different sites in Madurankuliya, Daluwa, Anuradhapura and Kuliyapitiya to determine the most suitable interval of treatment (1, 2, and 3 months).

Table 7 : Mean number of live coconut mites in different treatments

Treatment	Time after application (days)				
	15	30	45	60	90
40%	0	0	0	0	0.4(1)
30%	0	0	0	0	0.7(1)
20%	0	0.2 (1)	0	0.2(1)	1.1(1)
Control	721.7(10)	288.8(10)	496.7(10)	538.8(10)	474.3(10)

Number of nuts present in parentheses

Table 8 : Percentage of damaged nuts on treated (n=20) and untreated (n=10) bunches after 3 months of application of 30% oil

Damage status	Treated bunches		Untreated bunches (months)	
	4 month old	5 month old	2 month old	3 month old
Fresh damage				
Treated	2.1 (96)	0(101)	34.7(121)	27.1(122)
Control	80.0(80)	72.2(88)	42.3(104)	72.3(101)
Discontinued damage				
Treated	7.3	8.9	1.6	0.8
Control	11.3	11.3	1.0	2.0

Total number nuts in parentheses

Table 9 : Total number of predatory mites on nuts of different treatments at different intervals after treatment.

Treatment	Time after application (days)				
	15	30	45	60	90
40%	0	0	0	8 (1)	0
30%	0	7 (1)	2 (1)	5 (2)	0
20%	0	0	2 (1)	6 (2)	0
Control	15 (3)	27 (5)	57 (8)	24 (7)	8 (3)

Number nuts in parentheses

Table 10 : Mean number of live mites and total number of predators on treated and untreated palms at Anuradhapura

Days after treatment	Number of live mites		Number of predators	
	Treated	Control	Treated	Control
15	1.0 (4)	689 (10)	1 (1)	49 (6)
45	0.3 (1)	722 (10)	0	12 (4)
75	0.1 (1)	868 (10)	0	23 (5)
90	0.8 (2)	727 (10)	0	10 (3)

Number nuts with mites are in parentheses

Table 11 : Percentage of damaged nuts on treated (n=20) and untreated (n=10) bunches after 2 months of application of 30% oil

Damage status	Treated bunches (age – months)		Untreated bunches (age-months)	
	4	6	3	2
Fresh damage				
Treated	1.2 (160)	1.8(110)	48.8 (203)	42.2 (213)
Control	73.0(89)	70.1(77)	89.0 (82)	84.5 (97)
Discontinued damage				
Treated	20.6	63.6	2.4	0.5
Control	0.0	1.3	2.4	0.0

Total number nuts in parentheses

P. Fernando,K. A. S. Chandrasiri & R. Caldera

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 that was modified in the previous year 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 Kurunegala a mean numbers of 0.1 and 0.06 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 only in the cooler rainy months from October to December as in the previous years (Table 12). The experiment is in progress.

Table 12 : 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	24.4	0	0	0	0	0	0	0	0.6	0	0	0
BE	0.8	0	0.2	3.4	0	0	0	2.2	0.2	0	0	0.8
Walpita	0.7	0	0	0.1	0	0	0	0	0	0	0	0

P. Fernando, A Siriwardena, N. Fernando & R. Wijetunga

Experiment 28.2 : *Association of Fusarium spp. and nematodes in LSD (2002)*

A difference between the sap contents of LSD-affected palms and healthy palms were observed in the previous studies using Thin Layer Chromatography. Same results were obtained when the study was repeated with several samples.

S. Ranasinghe, P. Fernando & A. Siriwardena

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

Attempts were made to introduce the cell sap extracted from LSD-affected palms to about 100, 2-month old maize plants to determine whether scorching symptoms are produced on those palms. Injection of the sap into the plant was not successful. Therefore, introduction of sap was done by drenching 10 ml of the sap content in to the leaf axils. Observations made up to a one month indicated that 8 plants showed some scorching but it could not be confirmed since the drought was set in. The methods of treatment are being improved.

S. Ranasinghe, P. Fernando & A. Siriwardena

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

Experiment B26.5.4 : *In vitro evaluation of fungicides on mycelial growth and conidial germination of Ceratosystis paradoxa (2003)*

The study was conducted to identify effective fungicides that could inhibit mycelial growth and conidial germination of *Ceratosystis paradoxa*. Different concentrations of five fungicides, Captan, Previcur, Folicur, Monceren and Contaf were evaluated using poison food technique and conidial germination test. Folicur and Contaf inhibited the mycelial growth at all concentrations while Captan gave complete inhibition at 800 ppm (Table 13). Captan and Contaf inhibited conidial germination at all concentrations while Folicur gave complete inhibition above 100 ppm (Table 14).

Table 13 : Percent inhibition of mycelial growth of *C. paradoxa* by different concentrations of five fungicides (n =4)

Con. (ppm)	Captan	Previcur	Folicur	Monceren	Contaf
25	27.8	16.2	100	0	100
50	46.9	17.2	100	0	100
100	84.7	20.5	100	0	100
200	86.2	22.0	100	6.7	100
400	87.5	22.0	100	10.5	100
800	100	-	100	14.8	100

Table 14 : Percent inhibition of conidial germination of *C. paradoxa* by different concentrations of five fungicides (n =4)

Con. (ppm)	Captan	Previcur	Folicur	Monceren	Contaf
25	100	605	66	13	100
50	100	9.5	93	61	100
100	100	15.0	100	99	100
200	100	14.0	100	99	100
400	100	28.0	100	100	100
Control	6	6.5	4.8	4.8	100

P. Fernando, P. Manoj & K.F. G. Perera

Experiment B 26.5.5 : Evaluation of Contaf 5EC (Hexaconazole) and Folicur EW250 (Tubuconazole) for the management of leaf rot in the field (2002)

A field study was conducted in an estate at Matara district to determine the effectiveness of Contaf and Folicur on remission of disease symptoms. Different concentrations (10 ml and 20 ml) of Contaf and Folicur were treated to infected palms by trunk injection and drenching (n=6) for 4 times at 15 days intervals. Results 2 months after final treatment showed that trunk injection of both fungicides were not effective. Drenching showed promising results with only 2, 2, 3, 1 palms with infection in Folicur 10 ml, Folicur 20 ml, Contaf 10 ml and Contaf 20 ml treated palms respectively.

P. Fernando, I. Wickramanada, P. Manoj, G Perera & N G Premasiri

Experiment B 26.5.5 : Seasonal fluctuation of the incidence of fungi causing leaf rot disease (2002)

Ten affected sites in Matara District was selected and samples from each of 5 palms from each site were collected at 3 monthly intervals and the incidence of each fungus was recorded. *C. paradoxa* and *Fusarium solani* were the prominent fungi found on the samples (Table 15). Study is in progress.

Table 15 : Percentage of samples with *C. paradoxa*, *Fusarium solani* and *Colletrocrichum* species in different seasons

Month	*C. paradoxa*	*Fusarium solani*	*Colletrocrichum* sp.
November, 2002	12.4	18.8	0
February, 2003	40.8	40.4	1.6
May, 2003	32.9	22.4	0
August, 2003	34.4	30.0	0

P. Fernando, P. Manoj,K. F. G. Perera & N. G. Premasiri

3. CROP PROTECTION SERVICES

Incidences of pests and diseases

Eighty-eight 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 except in a plantation in Polonnaruwa area, which was reported to the Institute very late. 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 1914 vials were sold to the growers and CCB regional offices.
c. Chemical control: A total of 168 l of monocrotophos was issued to growers to control red weevil.

Table : Release of parasitoids in different provinces for the management of coconut caterpillar

Parasitoid	Western	North western	Southern	Eastern	Sabaragamuwa	Total
Eriborus trochanteratus	5800	31700	750	12450	1500	52200
Bracon hebetor	45500	203700	0	108000	0	357200
Goniozus nephantidis	750	19000	0	3000	0	22750
Brachymeria nephantidis	12450	67300	2400	20600	7000	109750
Total	64500	321700	3150	144050	8500	541900

4. TRAINING AND EXTENSION ACTIVITIES

Extension activities

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

Acknowledgements

I am grateful to the staff of Crop Protection Division for their dedication to the research programmes of the Division especially the coconut mite programme. Their cooperation and assistance in research and other activities during the year is greatly acknowledged. Sincere thanks are extended to the Head and staff of the Biometry Division for the assistance given in designing experiments and analysis of data. I thank Mrs. M. A. K Wijesinghe (Research Officer, Department of Agriculture) for her great contribution by conducting research on the *Hirsutella* fungus during the year. Advice of Professor J. G de Moraes, University of Sao Paulo, Brazil on predatory mite research and identification of mite specimens is immensely acknowledged.

REPORT OF THE BIOMETRY DIVISION
HEAD – D T MATHES, FIS

1. GENERAL

The division continued to assist the staff in statistical consultancy and computer related activities. The experiments on different frequencies of harvesting of coconuts, under different agroclimatic zones showed promising results. The work on "Impact assessment and adaptation to climate change in the plantation sector" funded by International START Secretariat, USA was continued during the year. This is a collaborative study with Agronomy and Plant Physiology Divisions. The meteorological stations at Bandirippuwa, Ratmalagara, Ambakelle, and Bogaswewa were maintained satisfactorily.

2. ASSISTANCE IN THE USE OF COMPUTERS AND COMPUTING

1. Continuous assistance was provided to all divisions on the use of application packages and System software.

   J D J S Kularatna and S S Rajapakse

2. Co-ordinated the work in maintaining the Personal Management System in the Establishment Division.

   S S Rajapakse

3. Assistance was provided for the installation of hardware and software. Co-ordinated activities of computers in the Institute.

   S S Rajapakse

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

   T S G Peiris, J D J S Kularatna, Kingsly Herath and P Fernando,

5. Computerizing and processing of information of the Medical Aid Scheme was continued.

   J D J S Kularatna

3. BIOMETRICAL ASSISTANCE

Assistance to the research staff was provided by way of statistical consultancy, selection of lands, layout of experimental designs, design of field surveys and questionnaires, analysis and interpretation of data.

Undergraduates from various universities were provided with special assistance in respect to their projects. In addition several postgraduate theses were supervised.

4. RESEARCH PROJECTS

PROJECT 13 : INFLUENCE OF HARVESTING PRACTICE ON NUT PRODUCTION (1997)

Experiment 13.0.1 : Frequency of harvesting

Since the beginning of 1990 the calibration trial at Walpita research substation was redesigned to evaluate the impact of harvesting at monthly intervals on coconut yield as compared to harvesting at two monthly intervals. In view of the promising results shown from this trial, two additional trials were established at Ratmalagara and Poththukulama research substations. The two experiments at Ratmalagara and Poththukulama comprised of four frequencies of harvesting; Viz. harvesting at 30, 60, 120 day intervals and not harvesting but collecting fallen nuts. Serious difficulty was experienced in getting a reliable recording of nuts from the fourth treatment as there is no harvesting being done. Hence recording of nuts from this treatment was dispensed with.

a. Results of the experiment at Walpita Research Substation

The number of nuts and copra yield per hectare are shown in Table 1.

Table 1 : *Number of nuts and copra yield*

Frequency of harvesting	Number of nuts per/ha/yr		Copra yield kg/ha/yr	
	Ave. 1993-2001	2002	Ave. 1993-2001	2002
Monthly	14542	11306	3127	2297
Two monthly	11159	8707	2271	1652
Difference No.	3383	2599	856	645
%	30.3	29.8	37.7	39.0

Monthly harvesting recorded a 30% higher number of nuts/ha/yr when compared to two monthly harvesting. The absolute increase during the year is in the range of 1 to 2 nuts per bunch. The overall average yields during the period 1993 to 2001 showed a similar yield difference between the two harvesting intervals.

b. Results of the experiment at Ratmalagara research substation

The impact of frequency of harvesting on yield is described in Table 2.

Table 2 : *Average number of nuts and fallen nuts*

Frequency of harvesting	Nuts/ha/year (Including fallen nuts)				% fallen nuts			
	2000	2001	2002	Ave	2000	2001	2002	Ave.
30 days	12900	13800	10975	12558	2.8	1.6	3.9	2.8
60 days	9825	11225	9475	10175	16.0	4.5	16.4	12.3
120 days	9075	10675	9574	9775	35.8	33.3	45.2	38.1

The average values given in table 2 describe the overall results for the period 2000 to 2002. There is clear evidence that harvesting at 30 day intervals showing a higher yield as compared to the other harvesting frequencies. Year 2002 showed a 15.8% more yield for 30 day harvesting as against 60 day harvesting. The average position over the three-year period is 23.4%. During the year 2002 harvesting at 60-day intervals showed 16.4 % nut fall when compared to 3.9% shown for monthly harvesting.

b. Results of the experiment at Poththukulama research substation

Number of nuts recorded for the three frequencies of harvesting is shown in Table 3. The year 2002 showed a 15.2% higher yields for 30 day harvesting compared to harvesting at 60 day intervals. This difference for the 3 year average is 17.3%.

Table 3 : *Average number of nuts and fallen nuts*

Frequency of harvesting	Nuts/ha/year (including fallen nuts)				% fallen nuts			
	2000	2001	2002	Ave.	2000	2001	2002	Ave.
30 days	14500	14650	10400	13183	1.1	2.4	5.8	3.1
60 days	12050	12650	9025	11241	9.9	10.9	22.2	14.3
120 days	8775	11650	8525	9650	30.0	39.3	58.9	42.7

The average fallen nuts during the year 2002 for monthly harvesting is 5.8% while that for the two monthly harvesting is 22.2%.

On the whole the three experiments clearly suggest the nature of benefits that could be achieved by harvesting nuts at monthly intervals.

D T Mathes, Ranjith Fernando, W M L G Fernando, Kingsly Herath, W E Fernando and W B P Fernando

Project 20.1 : Application of Climatology in Coconut Research

Experiment 20.1.2: Assessment of Impacts of and adaptation to climate variation for plantation sector in Sri Lanka with special reference to tea and coconut.

This project funded by UNEP/GEF commenced in July 2002. During this period daily rainfall data from 27 locations and daily minimum and maximum air temperature from six stations from 1932-2001 within the coconut growing areas were collected from the Department of Meteorology and analyzed in into Excel worksheets. Data were quantity controlled. The periods of available data over each selected station is shown in Table 4.

Table 4 : *Data available on the selected stations in each agro-ecological region*

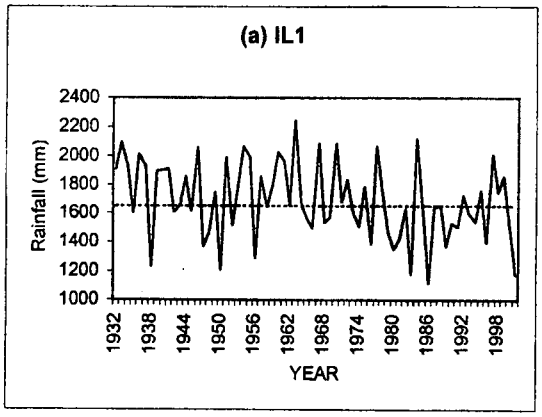
AGRO - ECO. REGION	STATION	PERIOD		
		RAINFALL	MAX. TEM	MIN. TEM
IL1	HORAKELLE	1932-2001		
	KURUNEGALA	1932-2001	1932-2001	1932-2001
	PALUGASWEWA	1932-2001		
	AMBAKELLE	1958-2001		
	BANDIRIPPUWA	1935-2001	1965-2001	1965-2001
	RATMALGARA	1939-2001		
IL3	NIKAWERATIYA	1941-2001		
	POLONTALAWA	1954-2001		
	RIDIBENDIELA	1937-2001		
	WARIYAPOLA	1932-2001		
	MEDIYAWA	1932-1999		
WL3	HUNUMULLA	1941-2000		
	KATUNAYAKE	1961-2001	1961-2001	1961-2001
	RAGAMA	1932-1999		
	WALPITA	1941-2001		
	PASYALA	1945-2001		
WL4	BADDEGAMA	1932-2001		
	GALLE	1932-2001	1932-2001	1932-2001
	KALUTARA	1932-2001		
	KEKANADURA	1932-2001		
WL2	POLGAHAWELA	1932-1988		
	AMBANPITIYA	1932-2001		
	KEGALLE	1932-1963		
DL3	PUTTALAM	1932-2001	1932-2001	1932-2001
	ANAMADUWA	1934-2001		
DL5	HAMBANTOTA	1932-2001	1932-2001	1932-2001
		1932-2001		

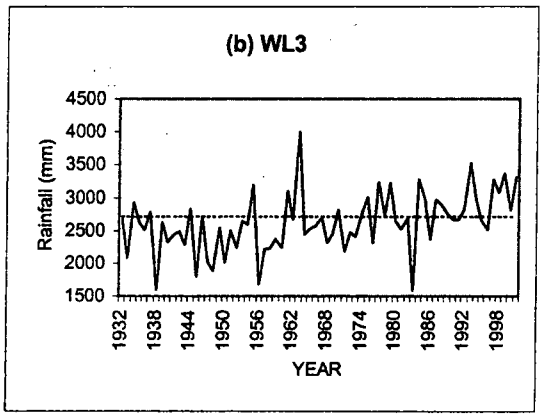
(L1 - Low country wet intermediate region; IL3 – Low country dry intermediate region; WL3, WL4 – Low country lower wet regions; WL2 – Low country moderately wet region; DL3 – Low country moderately dry region; DL5 – Low country higher dry region)

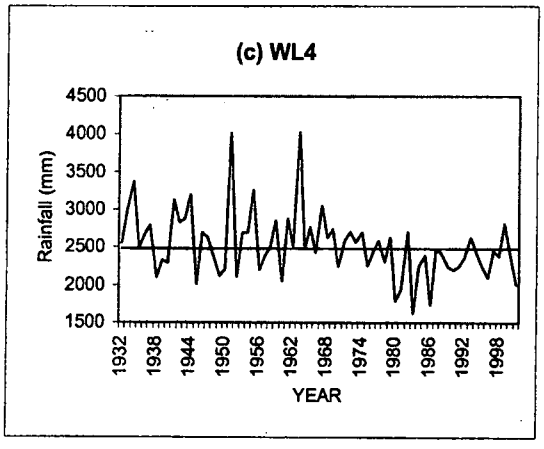
a. Trend in annual rainfall

The temporal behavior of the annual and seasonal climate in IL1, WL3 and WL4 were analyzed using the spatial averaged data of the locations within a region. There is a greater variability of annual rainfall between locations within a region than between agro-ecological regions. The annual rainfall variability in IL1 is lower (CV=15.6%) than that in WL4 and WL3. The annual rainfall variability in the three regions are shown in Figures 1(a) – 1(c).

Figure 1a–1c. Temporal variability of Annual Rainfall
(Dotted line represents the 1961-1990 average)







The annual variability in rainfall was compared with the average for the period 1961- 1990 as recommended by the Intergovernmental Panel on Climate Change (IPCC).

In both IL1 and WL4 regions, annual rainfall was above the 1961-1990 average (baseline) in most years prior to 1970 and thereafter it showed below the baseline average. In WL3 region temporal behavior with respect to baseline data is different from other two regions. Trend analysis for annual data revealed a significant increasing trend in WL3 and decreasing trend in other two regions (Table 5).

Table 5 : *Rate of annual increase (b) in mm/year.*

Rainfall	Agro-ecological Regions		
	IL1	WL3	WL4
Annual	-3.9	9.47	-7.43
First Inter Monsoon - FIM (March - April)	-1.5	1.74	-2.23
South West Monsoon – SWM (May – September)	.	5.04	.
Second Inter Monsoon – SIM (October – November)	.	.	.
North East Monsoon - NEM (December – February)	.	1.95	-1.62

(All the coefficients are significant at 5%)

The results in Table 5 indicate that there was a significant reduction in rainfall in IL1 for FIM period. A decreasing trend however was found for both FIM and NEM in WL4. Significant increasing trends can be seen in shown for the annual rainfall in all the seasons in WL3 except in SIM.

b. Trend in annual air temperature

All three regions showed significant increasing trends for maximum, minimum, mean and diurnal air temperature (Table 6). The annual rate of increase is higher for maximum air temperature in all three regions.

The results indicate that in all regions maximum temperature increment is highly responsible for warming of regions annually than that of the minimum temperature. To identify temporal behavior of maximum temperature within the seasons, linear trend analysis was carried out on seasonal basis (Table 7).

Table 6 : *Rate of annual increase (b) in ^{0}C/year*

Temperature	Agro-ecological Regions		
	IL1	WL3	WL4
Maximum	0.017	0.018	0.018
Minimum	0.003	0.017	0.005
Mean	0.010	0.017	0.012
Diurnal	0.014	0.001	0.012

(All the coefficients are significant at 5%)

Table 7 : *Rate of annual increase of maximum temperature in ^{0}C/year*

Season	Agro-ecological Regions		
	IL1	WL3	WL4
First Inter Monsoon - FIM (March - April)	0.023	0.033	0.021
South West Monsoon - SWM (May – September)	0.014	0.029	0.016
Second Inter Monsoon - SIM (October – November)	0.019	0.020	0.013
North East Monsoon - NEM (December – February)	0.020	0.021	0.025

The annual increment of seasonal maximum temperature is higher in FIM period in IL1 and WL3. These results confirm that the impact of climate change on coconut should be studied separately for agro-ecological zones.

T S G Peiris, W E R C Fernando, and C H Piyasiri

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 Divisio

6. AGRO-METEOROLOGY

The four meteorological stations at Bandirippuwa Estate, Ratmalagara Estate, Isolated Seed Garden and Maduru Oya Seed Garden at Bogaswewa were maintained. At Bandirippuwa, daily recordings were taken throughout the year on rainfall, air temperature (at 8.30 and 1530 hrs), evaporation, relative humidity (morning and afternoon), sunshine hours and soil temperature (at six different depths.)

Computerization of the meteorological data at Bandirippuwa Estate, Ratmalagara Estate, Isolated Seed Garden and Maduru Oya seed garden and providing information to Department of Meteorology and other Institutions were continued throughout the year.

Protus Fernando, J D J S Kularatna, and D T Mathes

6.1 Bandirippuwa Estate

a. **Rainfall** **(Table 8)** All months of the year experienced rainfall. The total rainfall for the year was 1779.0 mm. This rainfall is somewhat in par with the average recorded for the period 92-2001. A substantial increase in rainfall is shown for 2002 when compared to 2001. The months, January, February, July, August and September showed low rainfall. Month of October experienced a rainfall of 606.1 mm.

b. **Temperature (Table 8)** The monthly maximum temperature ranged from 30.4 (August) to 34.0^{0}C (February) while monthly minimum temperature ranged

from 21.8(February) to 24.9 (July). In general a higher temperature was recorded for the year 2002.

c. **Sunshine (Table 8)** Sunshine hours ranged from 5.4 (October) to 8.8 hrs./day (February). The average for the year was 7.0 h./day The year showed reduced sunshine hours compared to 2001. This is perhaps due to increased number of rainy days observed during the year.

d. **Evaporation.(Table 8)** The lowest and highest evaporation was recorded in November and March with values 3.1 and 4.9 respectively. The average for the year being 4.0 mm.

e. **Relative Humidity (Table 8)** The average relative humidity in the morning fluctuated around 82% during the year. In the afternoon it varied around 74%.

Table 8 : *Meterorological Data (Bandirippuwa Estate)*

	Rainfall (mm)			Temperature (C^0)		Evaporation (mm)	Relative Humidity (%)		Sunshine (Hrs)	Wind Velocity (Km/h)
	2001	92-2001 Ave.	2002	Max.	Min.		a.m.	p.m.		
January	83.1	66.2	5.2	32.6	21.8	4.4	79	65	7.2	5.0
February	40.4	65.8	23.2	34.0	21.8	4.9	74	62	8.8	5.5
March	26.2	55.8	165.0	33.2	22.6	4.9	79	65	8.0	3.7
April	266.6	214.0	258.5	32.5	22.7	4.3	81	73	7.8	3.0
May	43.4	243.4	240.7	31.9	24.2	3.5	82	81	6.2	4.4
June	37.4	121.4	87.8	30.5	24.4	3.6	84	80	6.6	4.9
July	18.3	79.3	4.0	30.5	24.9	4.0	84	77	7.7	5.7
August	5.1	81.9	48.7	30.4	24.4	4.1	83	77	7.3	5.4
September	164.8	193.4	34.7	31.4	24.2	4.3	77	70	7.7	0.0
October	142.0	320.7	606.1	30.5	22.3	3.2	87	77	5.4	0.0
November	170.9	294.1	213.6	30.8	22.8	3.1	88	82	5.6	0.0
December	56.8	94.2	91.9	30.8	22.3	3.5	84	76	6.0	0.0
Total	**1055.0**	**1830.2**	**1779.4**	**31.6**	**23.2**	**4.0**	**82**	**74**	**7.0**	**4.7**

6.2 Ratmalagara Estate (Table 9)

All months during the year experienced rainfall. The total rainfall was 1800.4 mm. This was greater than that experienced in 2001 and also compared to previous 10 year period. Low rainfall was observed for the months of January, February, June, July, August, and September.

6.3 Isolated Seed Garden (Table 9)

All the months except July recorded rainfall, with January, March, June, August and September experiencing low rainfall. The total rainfall for the year was 1644.3 mm., as against 964.6 mm., recorded in 2001. The total rainfall is higher than that recorded during the last 10 year period.

6.4 Maduru Oya Seed Garden (Table 9)

Except July, rest of the months experienced rainfall. The total rainfall recorded for the year was 1657.1 mm., which is lower than that recorded for 2001. Heavy rainfall was observed for the month of December amounting to 529.5 mm.

Table 9 *: Rainfall (mm) at Ratmalagara, Isolated Seed Garden and Maduru oya*

	Ratmalagara Estate			Isolated Seed Garden			Maduru Oya	
	2002	93-02 Ave.	2003	2002	93-02 Ave.	2003	2002	2003
Jan.	12.4	50.3	112.2	9.5	57.8	46.7	215.0	358.0
Feb	25.1	60.1	27.8	84.0	64.2	19.6	138.5	257.2
Mar.	80.9	47.3	177.8	23.6	52.1	161.3	23.0	88.9
Apr.	330.0	214.1	125.8	406.8	200.6	178.6	175.2	63.7
May	159.7	190.8	138.3	162.4	165.2	71.0	11.2	82.3
Jun.	73.8	75.9	264.3	70.8	63.2	162.0	5.9	26.2
Jul.	4.8	42.3	48.0	0.0	32.2	94.9	0.0	64.0
Aug.	9.6	49.3	5.4	10.1	32.6	14.5	8.2	27.1
Sep.	54.7	140.6	26.5	71.3	125.0	23.5	74.1	0.0
Oct.	445.5	357.1	251.9	453.3	276.9	217.4	197.5	114.7
Nov.	456.3	361.2	168.7	220.5	268.9	199.6	279.0	521.9
Dec.	147.6	112.3	16.6	132.0	138.5	22.3	529.5	156.9
Total	**1800.4**	**1701.3**	**1363.3**	**1644.3**	**1477.2**	**1211.4**	**1657.1**	**1760.0**

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, Kar Kar Tall, Markham Valley Tall, Renell Tall, Gazell Peninsula Tall, Thalasia Semi Tall, PNG Brown Dwarf, PNG Yellow Dwarf, Malayan Yellow Dwarf, Malayan Red Dwarf, Niaz Yellow Dwarf were brought from Papua New guinea (PNG) in August. These embryos were cultured and maintained under *in vitro* conditions. One hundred and eighteen plants raised from embryos (of 4 coconut varieties) brought from India were transferred to soil and over 100 plants are still growing in culture.

A total of 162 dikiri embryos were cultured during the year and 148 plants were acclimatized. Over 70 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 established at Lenawa Estate had been measured.

Twenty-one tissue-cultured coconut plants were planted at Bandirippuwa Estate to evaluate their performance in the field. 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 two of them (field planted at Bandirippuwa Estate in 1999) came into bearing. No abnormalities in vegetative growth or nut characters were observed in these palms. Microsatellite markers were used for testing genetic fidelity of clonal coconut plants that have already been established in the field. Thirty-one tissue-cultured coconut plants of 7 clones were analyzed and no variations were observed within a single clone.

The attempts to induce secondary embryogenesis in immature embryo and plumule- derived callus were unsuccessful. A study on the effect of epibrassinolide (a novel plant growth regulator) on callogenesis and somatic embryogenesis in plumule and immature inflorescence explants was initiated.

Highly friable callus was obtained from *in vitro*-cultured endosperm tissues and attempts were made to initiate cell suspensions using this material. A preliminary study revealed the presence of oil in immature endosperm-derived callus.

Studies on biochemical markers were continued to find any correlation between the biochemical characteristics of immature inflorescence explants and their morphogenic potential. A higher accumulation of total sugar was observed in –5 to –7 stages (taking the youngest open flower as 0) that also gave rise to a higher callusing frequency. Analysis of sugar profiles of inflorescence tissues of different maturity stages is underway to generate more information on biochemical markers.

A detailed histological study on inflorescence development was undertaken to aid in selecting the most suitable stage of immature inflorescence explants for *in vitro* culture. The study generated important information on floral bud initiation and their subsequent development

Investigations on unfertilized ovary culture for the production of double haploid plants were continued. Histological analysis of callus and somatic embryos derived from unfertilized ovaries revealed that these structures have originated from diploid tissues (carpels).

Preliminary investigations on micropropagation of papaw (*Carica papaya*) were initiated.

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 162 dikiri embryos were cultured (using the COGENT-upgraded coconut embryo culture protocol) during the year and 148 plants were acclimatized. Over 70 embryo-cultured dikiri plants were distributed among growers.

L K Weerakoon, T R Gunathilake, K P I E Ambagala and 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) that had been established at Lenawa Estate were measured.

L K Weerakoon, E S Santha and K P I E Ambagala

Experiment 18.1.7 : ***Germplasm exchange program***

Embryos of 10 coconut varieties namely, Kar Kar Tall, Markham Valley Tall, Renell Tall, Gazell Peninsula Tall, Thalasia Semi Tall, PNG Brown Dwarf, PNG Yellow Dwarf, Malayan Yellow Dwarf, Malayan Red Dwarf, Niaz Yellow Dwarf were brought from Papua New guinea (PNG) in August (Table 1). These embryos were cultured and maintained under *in vitro* conditions.

Table 1 : ***Establishment of embryo cultures with coconut germplasm brought from PNG***

Name of the Cultivar	Number of embryos cultured	Number of embryos contaminated/ damaged
Kar Kar Tall	238	3
Markham Valley Tall	274	7
Renell Tall	194	2
Gazell Peninsula Tall	205	5
Thalasia Semi Tall	181	3
PNG Brown Dwarf	196	3
PNG Yellow Dwarf	166	7
Malayan Yellow Dwarf	198	5
Malayan Red Dwarf	175	7
Niaz Yellow Dwarf	197	12

One hundred and eighteen plants raised from embryos (of 4 coconut varieties) brought from India were transferred to soil and many plants are still growing in culture (Table 2).

Table 2 : *Performance of coconut embryos collected from India*

Name of the Cultivar	Number of embryos cultured	Number of embryos contaminated/ damaged	Number of embryos germinated	Number of plants growing in culture	Number of plants transferred to soil for hardening
Andaman Ordinary	181	8	137	85	52
Laccadive Ordinary	220	30	100	80	20
Indian West Coast Tall	200	19	106	74	32
Banawali Green Round	132	11	68	54	14

L K Weerakoon, K P I E Ambagala, T R Gunathilake, , E S Santha, L Perera and J M D T Everard

18.2 : Studies on clonal propagation of coconut

Experiment 18. 2. 1 : *In vitro culture of immature zygotic embryos of coconut*

Attempts to induce secondary embryogenesis by repeated subculture of immature embryo-derived callus into embryo induction medium were unsuccessful. Eighteen clonal plants derived from immature embryo callus were planted in the field. The performance of the clonal plants, which were planted in the field in the previous years was found to be satisfactory.

L K Weerakoon, S C Fernando, E S Santha, and 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. The contents of total sugar and starch were determined in immature inflorescences of 5 developmental stages (–5 to –9 stages, considering the youngest open inflorescence as 0). The results revealed a higher accumulation of total sugar in –5 to –7 stages that might have some significance in morphogenesis, as these developmental stages also gave rise to a higher callusing frequency. Analysis of sugar profiles of inflorescence tissues of different maturity stages is underway to generate more information on biochemical markers.

A study on the effect of epibrassinolide (a novel plant growth regulator) on callogenesis and somatic embryogenesis in immature inflorescence explants was initiated.

H D D Bandupriya and L K Weerakoon

Experiment 18. 2. 5 : *Culture of plumule explants (1997)*

Previous studies indicated that regeneration capacity of callus originated from some of the plumules was higher than that of the others. Thus, plumules were excised from embryos collected from 60 selected palms and the embryo identity was maintained throughout the culture period in order to study any genotypic effect on plant regeneration potential. However, the callusing frequencies observed in different batches of plumules of the same palm were highly variable. Thus no correlation between the callusing frequency and mother palm could be observed. The study is being continued using the callus originated from the above plumules to study any genotypic effect on somatic embryogenesis and plant regeneration.

Usually, ABA is used to induce somatic embryogenesis in plumule-derived callus. In combination with ABA, the effect of the duration of cytokinin (BAP and 2iP) application, carbohydrate source (sucrose vs maltose), and organic nitrogen source (2.5-5.0 mM proline and glutamine) on somatic embryogenesis was studied. However, none of the treatments improved somatic embryogenesis.

The studies on the effect of the hormonal composition of the callus maintenance medium prior to somatic embryogenesis induction medium are in progress.

An experiment was initiated to investigate the effect of epibrassinolide on callus initiation in plumule explants.

During the year, 18 plants were regenerated from plumule-derived callus. Three of the plants were transferred to soil and the others are still growing in culture. A probable solution for the slow growth of clonal plants under *in vitro* conditions, is yet to be found.

S C Fernando and L K Weerakoon

Experiment 18. 2. 7 : *Studies on coconut anther, pollen and ovary culture (1997)*

A detailed histological study on inflorescence development was undertaken to aid in selecting the most suitable stage of immature inflorescence explants for *in vitro* culture. A series of inflorescences at different developmental stages (from –1 to –26 stages, considering the youngest open inflorescence as 0 stage; the most mature stage is -1 whereas the most immature stage is –26.) were used for the study. Development of an inflorescence in coconut is a very long process, which takes more than two years. The study revealed that this developmental process comprises of a series of individual events (Table 3). According to the results, fully developed ovules could be excised from pistillate flowers at –1 stage whereas anthers at –1 stage contain microspores with haploid nuclei. These findings will be very useful in selecting suitable explants (at the correct developmental stage) for haploid culture.

Investigations on unfertilized ovary culture for the production of double haploid plants were continued.

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 spathes
-24	Completion of the differentiation of external and internal spathes
-23	Further elongation of the inflorescence
-22	Differentiation of primary bracts
-21	Initiation of new primary bracts and elongation of the differentiated old bracts.
-20	Do
-19	Do
-18	Production of more bracts
-17	Initiation of rachillae
-16	Initiation of new rachilla and elongation of differentiated rachillae
-15	Initiation of secondary bracts
-14	Elongation of secondary bracts and initiation of pistillate flower buds (indicated by a mass of active cell clump) at the basal part of the rachilla
-13	Increase in the mass of active cells of pistillate flowers Initiation of staminate flowers (indicated by a mass of active cell clump)
-12	Increase in the size of active cell masses in both pistillate and staminate flowers and differentiation of new staminate flowers
-11	Do
-10	Do
-9	Differentiation of sepals in both pistillate and staminate flowers
-8	Do
-7	Differentiation of petals in both pistillate and staminate flowers
-6	Differentiation of ovary 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 pistil 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

Histological analysis of the somatic embryos derived from unfertilized ovaries revealed that some of them were complete embryos with proper shoot and root poles and haustoria. However, these structures have originated from diploid tissues (carpels). Thus attempts will be made to culture the ovules instead of ovaries, to increase the probability of producing haploid plants.

P I P Perera, L K Weerakoon and S C Fernando

Experiment 18.2.11 : *Studies on protoplast culture of coconut (2002)*

Attempts were made to isolate viable protoplasts from immature inflorescence tissues. The rachillae of immature inflorescences (6-8 months before splitting) were used as explants. The effect of different enzyme mixtures, pre-plasmolysing media, osmotica and digestion times on protoplast isolation was studied. Based on the results of all the preliminary experiments, a protocol was developed for viable protoplast isolation. It yielded viable (> 85 %) protoplasts (2 x 10^5 protoplasts per gram of tissue) of different sizes (10-70 μm).

Moreover, as the use of more mature inflorescences for culturing reduces the damage to the mother palm, isolation of protoplasts from pollen mother cells was also attempted. Anthers of inflorescences (2 months before splitting) were used for the study. The developed enzyme mixture was suitable for protoplast isolation from pollen mother cells. However, further studies are needed to find a method for separation of protoplasts/ pollen mother cells from tissue debris.

The presence of raphids in suspensions of protoplasts isolated from coconut tissues, made the separation of protoplasts from tissue debris by centrifugation difficult. Therefore, attempts were also made to isolate protoplasts from embryogenic callus of coconut. The above protocol was found to be suitable for isolation of protoplasts from embryogenic callus.

The protoplasts isolated from various tissues were cultured in media supplemented with various combinations of hormones (2,4-D and BAP) and antioxidants (charcoal and PVP). However, suitable conditions for protoplast division are yet to be identified. Further studies to increase the protoplast yield and develop suitable conditions for protoplast culture are in progress.

S C Fernando

Experiment 18.2.12 : *Studies on endosperm culture of coconut (2002)*

Endosperm tissues collected from micropylar region of 9-month old nuts (sterilized in 3% calcium hypochlorite for 5 min) were cultured in solid Y3 medium supplemented with 28.5 μM IAA and 2.2 μM BAP. Three to four weeks after inoculation, necrotic regions could be seen in about 50% of the explants. After another four weeks, some of the explants initiated callus directly on the surface of necrotic tissues whereas in the others, callus was initiated in the inner region of necrotic tissues and became visible when the endosperm tissues were opened into two halves. The callus was watery and highly friable.

The callus could be multiplied by subculturing into the same medium at 8-week intervals but no further differentiation was observed during subculture.

In order to establish suspension cultures, the friable callus was suspended in the liquid Y3 medium supplemented with 28.5 μM IAA and 2.2 μM BAP with or without activated charcoal. In the absence of charcoal, the callus showed severe browning whereas in the presence of charcoal, the callus growth was slow. Microscopic observations revealed the presence of

single cells, dividing cells and small cell colonies in the suspension. However, maintaining of the suspensions was difficult due to the presence of charcoal.

A preliminary study showed the presence of oil in immature endosperm-derived callus.

S C Fernando

Experiment 18.2.13 : *Studies on the quality of in vitro-raised plants (2002)*

A previous study indicated that different acclimatization procedures (acclimatization in potting mixture with and without rooting hormone application and acclimatization using hydroponics) of *in vitro*-raised coconut embryo-cultured plants had no significant effect on plant growth during the first three months of acclimatization. However, root dry weight to shoot dry weight ratio of plants grown using hydroponics was significantly higher than that of plants grown in potting mixture. Even though it did not reflect on plant growth during the first three months of acclimatization, it might be effective during later period of acclimatization.

Therefore, plants acclimatized for three months using the above three procedures were maintained in potting mixture of un-sterilized top soil, dried cow dung and coir dust (2:2:1) for further evaluation after six months of acclimatization.

The results revealed that the height of plants initially grown in hydroponics for three months was significantly lower than that of control and rooting hormone-treated plants (Table 4). As a result, the shoot dry weight of these plants was also lower when compared to the other plants. However, the ratio of root dry weight to shoot dry weight of plants grown in hydroponics was significantly higher. This increase in the root dry weight to shoot dry weight ratio might be advantageous to the plant to get established in the field.

Table 4 : *Growth performance of plants after 6 months of acclimatization*

Treatment	No of newly emerged leaves	Plant height (cm)	Total number of primary roots	Shoot DW (g)	Root DW (g)	Root DW / Shoot DW
Control (Potting mixture without hormone application)	4.8	76.5 [a]	7.0	19.6 [a]	6.08	0.31 [a]
Potting mixture with hormone application	4.0	89.5 [a]	8.0	24.2 [a]	6.46	0.28 [a]
Hydroponics	4.0	49.0 [b]	5.4	7.9 [b]	3.24	0.41 [b]
Significance	NS	P=0.006	NS	P=0.02	NS	P=0.002
CV (%)	13.7	18.5	30.0	40.9	35.3	9.8

DW = Dry weight; NS = Not significant.

S C Fernando

Experiment 18. 2. 14: *Micropropagation of high-value crops (2002)*

Preliminary investigations on micropropagation of papaw (*Carica papaya* cv. Red lady) were initiated using shoot tips from seedlings as explants. The highest shoot proliferation was observed in MS medium supplemented with 0.5 mg/L BAP and 0.01mg/L NAA. To promote shoot growth, 0.25 µM GA_3 was incorporated to the medium at the third sub culture. MS medium containing 1 mg/L IBA was used for root induction and 40 % of the shoots produced roots when cultured to this medium.

H D D Bandupriya

Experiment 18.2.15 : ***Molecular studies of clonal coconut plants (2003)***

Microsatellite markers were used for testing genetic fidelity of clonal coconut plants. Thirty-one tissue-cultured coconut plants (13 derived from immature embryo callus, 9 derived from meristem callus, 7 derived from plumule callus and 2 derived from leaf callus) of 7 clones were analyzed using 10 highly polymorphic microsatellite primers. No variations were observed in plants within a single clone.

RAPD analysis of the above clones is in progress.

S C Fernando

3. ACKNOWLEDGMENTS

The assistance and co-operation of the staff of the Tissue Culture Division in conducting the experiments and compiling this report are gratefully acknowledged. Thanks are due to the Head and the staff of the Biometry Division for the assistance given in designing the experiments. Special thanks are extended to the Head and the staff of the Plant Physiology Division for their assistance in biochemical analysis of coconut tissues.

REPORT OF THE COCONUT PROCESSING RESEARCH DIVISION

Officer in Charge - C Jayasekara, Ph.D (Qld)

GENERAL

The research program of the Coconut Processing Research Division during the year 2003, has given more emphasis on developing kernel based value added products. Trials were carried out to compare the varietals differences of CRIC 60 and CRIC 65 on DC out turn both quantitatively and qualitatively. Result revealed that DC out turn of CRIC 60 is better than that of CRIC 65. To extend the use of coconut kernel, coconut jams were prepared with tender coconut and mature coconut. Sensory evaluation revealed that both tender and mature coconut can be used to process quality jam with smooth texture.

Experiments were also carried out to find out the effect of household extraction methods on composition of coconut milk. Significantly higher yield of fat in coconut milk was obtained by blending followed by hand squeezing. The yield was significantly higher in hot water extraction irrespective of the type of extraction method used.

Virgin coconut oil and value added virgin coconut oil were produced with the use of a cold pressing expeller. The virgin coconut oil which is expelled at lower temperature is very clear and transparent and may find many applications in the cosmetic industry. Defatted coconut residue, resulting from this process is whitish in colour and has an appealing smell, taste and texture. This was found to be suitable as a raw material for the preparation of spread cheese, instant thosa sambol etc.

Improvement to copra drying is another activity undertaken by the division. Modifications were done to the existing Ceylon Copra Kiln with the objective of improving the quality of copra by the use of charcoal powder as fuel.

Experiments were also conducted to find out the effect of sodium metabisulphite (SMS) and heat treatment on ethanol production and keeping quality of bottled toddy. The samples, which were treated with 150 ppm SMS and pasteurized either at 70 ^{0}C for 30 minutes or at 80 ^{0}C for 20 minutes and stored at room temperature showed 8.1+/- 0.2 % and 8.0+/- 0.2 % alcohol contents respectively, on 6 months of storage.

Experiment 01 : Effect of sodium metabisulphite and heat treatment on ethanol production and keeping quality of bottled toddy

Sap was treated with 0- 150 ppm sodium metabisulphite under laboratory conditions and alcohol content was measured for 10 days to identify the highest alcohol percentage and the day on which it was formed. The highest alcohol percentage was recorded on the 5 th day of fermentation at each sodium meta bisulphite concentration. The results are given in table 01.

Table 01 : *The mean alcohol percentage at each sodium metabisulphite concentration on the 5 th day of fermentation*

Sodium meta bisulphite(SMS) Concentration (ppm)	Alcohol %+/-SE
Control	7.1+/-0.2
50	7.8+/-0.1
100	7.9+/-0.2
150	8.5+/-0.2

According to the table the highest alcohol percentage of (8.5+/-0.2) was observed at150 ppm SMS. The samples with 150 ppm SMS were bottled and pasteurized at different temperatures (70 ^{0}C, 80 ^{0}C and 90^{0}C) at different times (20 min, 25 min and 30 min) and stored at both room temperature and refrigerated temperature.

The alcohol content was measured at monthly intervals for a period of 6 months to check the keeping quality. The results are given in table 02 and 03.

Table 02 : *The mean alcohol content of samples on 6 months of storage at room temperature*

Temperature ^{0}C	Time	Alcohol content %					
		1st month	2nd month	3rd month	4th month	5th month	6th month
70	20	8.1	8.0	8.0	7.9	7.9	7.8
70	25	8.1	8.0	7.8	7.9	7.8	7.8
70	30	8.0	8.3	8.1	8.2	8.2	8.1
80	20	8.0	8.2	8.0	8.0	8.0	8.0
80	25	8.0	7.9	7.9	7.8	7.9	7.8
80	30	7.9	7.6	7.7	7.7	7.8	7.8
90	20	7.7	7.9	7.7	7.7	7.5	7.6
90	25	7.7	8.0	7.5	7.3	7.6	7.6
90	30	7.7	7.9	7.8	7.8	7.6	7.7

Table 03 : *The mean alcohol content of samples on 6 months of storage at refrigerated temperature*

Temperature	Time	Alcohol content %					
		1st month	2nd month	3rd month	4th month	5th month	6th month
70	20	8.1	8.0	7.7	7.5	7.5	7.3
70	25	8.1	7.9	7.5	7.5	7.4	7.1
70	30	8.0	7.8	7.1	6.9	6.7	6.5
80	20	8.0	6.5	6.5	6.5	6.5	6.2
80	25	7.6	6.7	6.7	6.7	6.8	6.6
80	30	7.9	6.7	6.7	6.4	6.4	6.3
90	20	7.6	7.5	7.5	7.5	7.3	7.1
90	25	7.7	7.7	7.0	6.5	6.5	6.5
90	30	7.1	6.0	6.0	6.2	6.2	6.0

According to statistical analysis based on ANOVA, the significantly better ($P<0.05$) pasteurized conditions were pasteurization at 70 ^{0}C for 30 minutes or pasteurization at 80 ^{0}C for 20 minutes. The significant ($P<0.05$) alcohol percentage was obtained at room temperature compared to that of refrigerated temperature on 6 months of storage. The samples, which were pasteurized at 70 ^{0}C for 30 minutes or at 80 ^{0}C for 20 minutes and stored at room temperature showed 8.1+/- 0.2 % and 8.0+/- 0.2 % alcohol contents respectively on 6 months of storage.

M.Jayasundera ,P.A.D.W.B.Piumi and V. Wijeratne

Experiment 2 : The Modifications to the existing Ceylon Copra Kiln

The Modified Ceylon Copra Kiln is similar to the Ceylon Copra Kiln except for a few changes made to the firing chamber dimensions.

The modified Kiln consists of 5 firing chambers, each of which has the following dimensions.

Height [fire bed (floor) to drying platform] - 1.2 m

Width - 2.0 m

Length - 3.7 m

Cement floor

Each chamber has a capacity for drying 1500 nuts.

0peration schedule for dry season

Day	Time	Operation
1	7.00 a.m. 5.00 p.m.	Split the nuts and sun-dry on the cement floor Load the drying platform with halves of 1500 nuts Arrange charcoal powder (45 kg) in three rows of 15 kg each and start firing (1 st firing)
2	3.00 p.m. 5.00 p.m.	Mix halves (exchanging cups in the front and rear ends of the drying platform) Arrange charcoal powder (45 kg) in three rows of 15 kg each and start firing (2 nd firing)
4	12.00 noon 5.00 p.m.	Remove the shells Arrange charcoal powder (30 kg) in 2 rows of 15 kg each and start firing (3 rd firing)
5	5.00 p.m.	Drying complete and cups are ready for storage (Copra produced contain 7+/-1 % moisture)

Operation schedule for rainy season

Day	Time	Operation
1	7.00 a.m.	Split the nuts and load the drying platform with halves of 1500 nuts Arrange charcoal powder (60 kg) in four rows of 15 kg each and start firing (1 st firing)
2	7.00 a.m.	Arrange charcoal powder (60 kg) in four rows of 15 kg each and start firing (2 nd firing)
3	7.00 a.m. 10.00 a.m.	Mix halves (exchanging cups in the front and rear ends of the drying platform) Arrange charcoal powder (45 kg) in three rows of 15 kg each and start firing (3 rd firing)
4	7.00 a.m. 10.00 a.m.	Remove the shells Arrange charcoal powder (30 kg) in 2 rows of 15 kg each and start firing (4 th firing)
5	5.00 p.m.	Drying complete and cups are ready for storage (Copra produced contain 7+/-1 % moisture)

M. Jayasundera, U. Samarajeewa, A.R. Kulatunga and M. Rajapakse

Experiment 3 : Improvement to the quality of bottled coconut oil

Experiment 3.1 : Studies on centrifugation of bottled coconut oil to reduce sedimentation

The appearance of bottled white coconut oil deteriorates with time due to sedimentation. In order to overcome this problem the coconut oil samples were subjected to centrifugation at different speeds.

Treatments

i. Control
ii. Centrifugation at 1000 rpm at 20 ^{0}C for 20 minutes
iii. Centrifugation at 3000 rpm at 20 ^{0}C for 20 minutes
iv. Centrifugation at 5000 rpm at 20 ^{0}C for 20 minutes
v. Centrifugation at 21000 rpm at 20 ^{0}C for 20 minutes

Deep fried foods (wadai) were prepared with the treated and the untreated oil (control). Sensory properties of the treated oils, the control and wadai were evaluated by 30 untrained panelists for taste smell and overall acceptability.

Statistical analysis of sensory evaluation indicated that there was no significant difference among the control and the treated samples ($P>0.05$), no significant difference among the treated samples ($P>0.05$) and also no significant difference for wadai prepared with the treated oils and the control ($P>0.05$).

Since there was no significant difference in taste, smell and overall acceptability between the treated and the control, the treated oils were as good as the control.

For further clarification, chemical analysis was done for the control and the oil sample subjected to the highest centrifugal speed of 21000 rpm at 20 ^{0}C for 20 minutes.

Table 03 shows the mean chemical parameters of the control and treated oil.

Table 03 : *Mean chemical parameters of the control and the treated oil*

Sample	Moisture %	FFA %	Impurity %	Protein %	Ash %
Control	0.64	0.27	0.10	0.65	0.00
Treated (21000 rpm @ 20 ^{0}C for 20 min.)	0.25	0.25	0.63	0.63	0.00

Each figure is a mean value of 3 analyses.

There was no significant difference (P>0.05) between the control and the treated, with respect to the FFA, protein and ash content. Moisture and impurities were significantly lower in the treated oil compared to those of the control.

The treated samples were stored at room temperature to check for sedimentation. It was observed that there was no sedimentation up to 3 months of storage. However, sedimentation was observed after 3 months of storage. Therefore, a better filtration system is now being designed for over 3 months storage without sedimentation.

C. Yalegama, M. Jayasundera and A.N. Kumara

Experiment 4 : Dry processing of virgin coconut oil and value addition to virgin coconut oil

Virgin coconut oil and value added virgin coconut oil are being produced with the help of a cold pressing expeller. The oil is expelled at less than 60 ^{0}C.The scraped coconut is dried at less than 70 ^{0}C to a moisture content of less than 2 % before being fed into the expeller. The oil expelled shows the following analytical parameters (Table 04).

Table 04 : *Mean analytical parameters of virgin coconut oil*

Moisture %	0.2
FFA % as lauric acid	0.04
Iodine Value	6.4
Peroxide Value, meq/kg	ND

Table 05 shows the fatty acid composition of virgin coconut oil.

Table 05 : *Fatty acid composition of virgin coconut oil*

Fatty Acid	Percentage
Caproic acid (C6)	0.2
Caprylic acid (C8)	7.8
Capric acid (C10)	6.5
Lauric acid (C12)	50.6
Myristic acid (C14)	19.5
Palmitic acid (C16)	6.5
Stearic acid (C18)	1.9
Oleic acid (C18: 1)	4.5
Linoleic acid (C18: 2)	2.5

Shelf-life studies are being continued.

Three types of value added virgin coconut oils were produced. They were the oil blends of 5 % cumin seed and 95 % coconut, 2.5 % chillies and 97.5 % coconut and 10 % dried carrot and 90 % coconut. Chemical analyses are being carried out.

M.Jayasundera, C.Yalegama, A. Dharmasena and S.Jayatilaka

Experiment 05 : Utilization of defatted coconut residue

Defatted coconut residue, resulting from cold pressing is white in colour because it does not undergo condensation of protein and sugar during expulsion of oil. Consequently the residue has a bland smell, taste and flavour. The chemical composition of the residue is given in table 06.

Table 06 : *Chemical composition of defatted coconut residue*

Moisture %	Protein %	Fibre %	Mineral %	Fat %	Carbohydrate %
4.5	19.7	38.4	4.5	2.7	30.2

Each value is a mean of 3 figures.

Preliminary studies indicate that this residue could be used in many food items such as spread cheese, bakery products (bread and buns) and 'instant thosai sambol'.

Chemical analysis was carried out for spread cheese and 'instant thosai sambol'. The results are given in tables 07 and 08

Table 07 : *Chemical composition of Spread cheese*

Moisture %	Protein %	Fibre %	Mineral %	Fat %	Carbohydrate %
49.4	6.4	21.1	2.0	19.1	2.0

Each value is a mean of 3 figures.

Table 08 : *Chemical composition of 'Instant thosai sambol'*

Moisture %	Protein %	Fiber %	Mineral %	Fat %	Carbohydrate %
5.1	21.5	40.0	5.9	8.7	18.8

Each value is a mean of 3 figures.

Further experiments are being carried out in making other food items with defatted coconut residue.

M. Jayasundera, C. Yalegama, A.N.Kumara, A. Dharmasena and A. Milroy

Experiment 06 : Formulation of a dish wash bar and a dish wash powder with grade 3 coconut oil at low cost

A dish wash bar and a dish wash powder were formulated with grade 3 coconut oil. Recipes were developed for both dish wash bar and dish wash powder
Recipe developed for dish wash bar is as follows

Coconut oil 550 g
Caustic soda solution (100 g dissolved in 280 g of water)
Kaolin 100 g
Dolomite 950 g

Recipe developed for dish wash powder is as follows

Soap 150 g
Water 300 g
Dolomite 1250 g

Soap (150 g) was dissolved in 300 g of water and was mixed with 1250 g of dolomite. The mixture was dried in an oven at 105 ^{0}C for 30 minutes. Once the drying was complete it was ground into a powder.

Improvements are being made to increase the cleansing properties and dour.

M.Jayasundera, A.N. Kumara and M. Rajapakse

Experiment 07 : Analysis of Proximate composition of Dikiri Coconut (*Cocos nucifera* L), Isolation and characterization of its pectin:

There are many improved varieties of tall and dwarf that provides a good yield. Apart from these vareities, a peculiar form of coconut is found from the southern parts of Sri Lanka. Dikiri is a coconut with an abnormal endosperm. There are few other examples for this particular form of coconut from other coconut growing countries e.g. "Makapuno" in the Philippine. This Dikiri coconut differ from other normal coconut with a gelatinous endosperm instead of the hard, crispy endosperm and water found inside in ordinary coconut (Ohler, 1984). Though potential of this special form of coconut is not utilized for the development of new products in Sri Lanka, Makapuno in Philippine which bears many similarities to Dikiri has been subjected to many research to produce a variety of sweets and frozen desserts.

Table 10 : *Proximate composition of Dikiri coconut*

Constituents	Dikiri coconut (%)	TXT coconut (%)
Moisture	68.70	43.60
Fat	34.45 (dw)	66.11 (dw)
Protein	6.75 (dw)	6.14 (dw)
Fiber	11.58 (dw)	5.08 (dw)
Ash	2.13 (dw)	1.86 (dw)
Carbohydrate(by difference)	45.09 (dw)	20.81(dw)

dw -dry weight basis

Studies on Makapuno endosperm have showed that its cell wall compounds have a high level of pectin than non-Makapuno coconut (Roasiro and Gabuya, 1980). The proximate composition of Dikiri kernel was determined by measuring moisture, crude protein crude fat, ash, crude fiber and carbohydrate by using AOAC 1990.

Pectin from Dikiri coconut was isolated and was characterized using the method described by AOAC, 1995.

Table 11 : *Pectin content of Dikiri, Wood apple and Pumpkin*

	Pectin
Dikiri	7.20%
Wood apple	8.88%
Pumpkin	6.48%

Table 12 : *Charecterization of Dikiri Pectin*

	Dikiri Pectin	Commercial Pectin
1 Equivalent weight	900.97	836.83
2 Methoxyl content	11.41	9.58
3 Acetyl value	0.089	0.068
4 Ash	0.855%	0.865%

K.D.P.P.Gunathilake and D.N.H.Satharasinghe

Experiment 08 : Evaluation of suitability of DGXT (CRIC 65) and TXT (CRIC 60) cultivars for Desiccated coconut manufacture:

Total DC production in year 2000 was 89030 MT and it represent about 28% total coconut production. There are various factors, which affect the outturn and quality of DC, and the genetic factor, i.e. variety of the coconut is one of them. Though CRIC 60 and CRIC 65 were introduced several decades back they have not been subjected to an extensive study with regards to DC manufacture. So, main objective of this experiment is to compare CRIC 60 and CRIC 65 varieties on DC manufacture, quantitatively and qualitatively.

Four trials on DC manufacture were conducted at Dunagaha DC mill. Desiccated coconut out-turn, chemical composition and sensory properties were identified

Table 13 : *DC out-turns at four trials (Kg DC/1000 nuts)*

DGXT (CRIC 60)	TXT(CRIC 65)
124.28	148.30
125.21	127.76
133.63	140.22
124.28	142.50
Avg: 126.85	**Avg: 139.70**

It was found that in average 139.70 kg DC could be obtained from 1000 nuts of TXT variety, whereas 126.85 kg can be yield from DGXT variety.

Table 14: *Chemical composition of DGXT and TXT*

	DGXT	TXT
Protein	7.93	7.80
Moisture	1.83	1.27
Fat	68.29	70.59
Ash	1.58	1.62
Fiber	10.68	12.39
Carbohydrate	3.39	3.364

Further studies are being carried out to identify sensory profile and the fatty acids profile.

K.D.P.P.Gunathilake, C.Yalegama and A.N.Kumara

Experiment 09 : Effect of household extraction methods on composition of coconut milk

Coconut milk varies in composition depending not only on the variety used but also on the amount of water added for the extraction and the method of preparation of coconut milk. An experiment was conducted to identify different household extraction methods used to extract coconut milk and to determine the effect of different extraction methods on the composition of coconut milk. Proximate composition of coconut milk extracted by different household methods was analyzed using standard AOAC procedures (AOAC, 1999) and fatty acids profile in the extracted coconut milk was analyzed using gas chromotography.

Table 15 : *Different methods of coconut milk extraction practiced by households*

Extraction methods and condition of water	Household (%)
1. Hand squeezing- cold water	68
2. Hand squeezing- hot water	10
3. Blending -cold water	8
4. Blending -hot water	6
5. Grinding -cold water	6
6. Grinding-hot water	2

Majority of households extracts coconut milk by hand squeezing. The second and third most commonly used methods are blending followed by hand squeezing and grinding followed by hand squeezing respectively.

Table 16 : *Type of extractions of coconut milk used for cooking by households*

Type of extractions	Households (%)
First milk only	2
First and second milk only	32
First, second and third milk only	60

Table 17 : *Fat and Protein content in coconut milk extracted by different extraction methods*

Method of extraction	1st milk		2nd milk		3rd milk	
	Fat	Protein	Fat	Protein	Fat	Protein
1. Hand squeezing-cold water	15.32	0.88	3.57	0.39	1.28	0.20
2. Hand squeezing-hot water	19.07	1.22	4.56	0.66	1.29	0.23
3. Blending -cold water	20.03	1.96	5.56	0.67	1.49	0.17
4. Blending -hot water	24.59	1.52	6.01	0.53	1.64	0.13
5. Grinding -cold water	16.19	2.21	4.46	0.55	1.32	0.26
6. Grinding-hot water	21.39	2.07	4.67	0.63	1.67	0.28

It was found that significantly higher yield of fat in coconut milk was given by blending followed by hand squeezing whereas it was significantly higher in hot water extraction irrespective of the type of extraction method used. It was found that grinding followed by hand squeezing with cold water was given the highest protein content in first mi

Table 18 : *Fatty acids profile of first milk (%) obtained by different extraction methods*

Classes of fatty acids	Type of fatty acids	Hand squeezing-cold water	Hand squeezing- hot water	Blending -cold water	Blending -hot water	Grinding - cold water	Grinding-hot water
Short chain	Caproic C_6	0.72	0.17	0.57	0.54	**0.76***	0.54
	Caprylic C_8	9.91	6.62	8.08	8.77	**10.40***	7.95
	Capric C_{10}	6.82	5.26	6.01	6.22	**6.83***	5.74
Medium chain	Lauric C_{12}	**49.59***	46.12	46.4	49.19	45.73	48.92
Long chain	Myristic C_{14}	20.05	**21.11***	20.59	19.10	18.75	19.32
	Palmitic C_{16}	8.51	8.96	8.56	**9.96***	7.83	8.38
	Stearic C_{18}	0.10	0.23	**1.05***	0.50	0.90	0.45
	Oleic $C_{18:1}$	4.27	**7.91***	5.73	6.73	6.23	5.34
	Linoleic $C_{18:2}$ and Linolenic $C_{18:3}$	3.06	**3.56***	2.95	2.99	2.61	3.33

Methods X treatment interactions are significant $p<0.0001$
*Means are significantly different (at $p=0.05$) from other methods

The proximate composition and fatty acids profile of coconut milk extracted by different extraction methods are different. Highest amount of proteins and short chain fatty acids can

be obtained simultaneously when coconut milk is extracted by grinding followed by hand squeezing using cold water rather than other extraction methods.

K.D.P.P.Gunathilake, C.Yalegama, H.G.N.Hiniduma and H.Marambe

Experiment 10 : Preparation and evaluation of market potential for coconut jam

Studies on preparation of coconut jam from tender coconut was mature coconut were evaluated. Use of 1kg coconut pulp, 1% added pectin, 0.75% titratable acidity and 750g sugar resulted in smooth textures, good jam. Sensory evaluation revealed that both tender and mature coconut can be use to process quality jam with smooth texture.

Table 19 : *Proximate Composition of tender coconut jam*

Constituents	levels
Moisture	12.00%
Fat	9.65 %
Protein	1.00%
Fiber	2.50%
Ash	0.35%
Carbohydrate	74.50%
Total soluble solids	65^0
Titratable acidity	0.75%

Coconut jam is a new coconut based product produced from the coconut kernel. Though many other fruit jam and marmalade types are already available in the market, people are unfamiliar of the name of coconut jam. Therefore a market survey was conducted at Chilaw urban area. Seventy households were randomly selected for the market survey and they were given free samples. After one weeks time, enumerators re-visited each household to get the responses of the consumers. Responses are given in following tables

Table 20 : *Consumer satisfaction and quality preferences for coconut jam*

Response	Percentage
1.Quality is better than other jams	32%
2.Quality is similar to other jams	37%
3.Satisfy with further improvement	32%
4.Not satisfy	0

Table 21 : *Consumer suggestions for product development of coconut jam*

Suggestions	Percentage
1.None needed	36%
2.Free of coconut oily taste	30%
3.Addition of fruit taste	9%
4.Texture to be more thicker	14%
5.Improvement in colour	9%

Based on this survey results further quality improvements are being carries out.

K.D.P.P.Gunathilake, A.N.Kumara, S. Jayathilake, A. Milroy and S.Samrajeewa

CESS Funded Projects

Experiment 11 : Survey on quality of coconut oil

Coconut oil samples were collected randomly from different areas covering Gampaha, Anuradhapura, Kurunegala, Kegalle and Galle districts. The samples were analysed for physical and chemical parameters.

According to the physical observations, almost all the samples were clear and were yellow in colour. But the smell varied from good coconut oil smell to rancid smell.

Ten samples were collected from Kurunegala area. Free fatty acid content of all the samples was less than 1.0 %. Moisture content varied from 0.1% to 0.8 %. Peroxide value varied from 0.01 to 0.46 meq/kg. Iodine value varied from 8-14.

Fifteen samples were collected from Ruwanwella and Gampaha areas. Free fatty acid content of all the samples were less than 1.0 % and moisture content varied from 0.2 to 0.8 %. Peroxide value varied from 0.10 to 0.05 %. Iodine value varied from 10-18 meq/kg.

Fifteen samples were collected from Anuradhapura area. Among them, free fatty acod content of 11 samples were 1.0 % and 4 samples showed 1.2 %, which is slightly higher than the standard value. Moisture content of 7 samples was less than 0.4 % and other samples showed higher values. Peroxide value of all the samples was less than 0.10 meq/kg and Iodine value showed higher values 10-16.

Twenty samples were collected from Galle area. Moisture content of all the samples was less than 0.5 %. Free fatty acid content of 9 samples was less than 1.0 % and the 11 samples showed higher free fatty acid content. Iodine value of 2 samples conformed to the Iodine value of coconut oil while others were higher than the standard value. Peroxide value of 11 samples showed less than 1meq/kg and other samples gave higher values.

According to the SLS standards edible coconut oil should have followed chemical properties.

Free fatty acid content - < 1.0%
Moisture content - < 0.4%
Iodine value – 7-9.5

When compared with the standard value chemical properties of some of the samples are not within the required limits indicating that there can be impurities or contaminations in coconut oil analysed. The survey is being continued.
Samples from Kurunegala area were analysed for fatty acid composition. All the samples showed 43- 53 % Lauric acid content indicating that samples are free from adulteration.

C.Yalegama and A. Dharmasena

REPORT OF THE PLANT PHYSIOLOGY DIVISION
Head – C S Ranasinghe, Ph D

1. SUMMARY

A new research project was initiated to determine the effect of drip irrigation on micro climatic conditions of the coconut canopy and nut setting during dry periods. A series of experiments were started to strengthen basic knowledge on growth and performance of the root system of coconut seedlings under different stress conditions (land suitability classes and micro nutrient deficient conditions). The ongoing research projects on field evaluation of PEG-screened embryo-cultured plants for drought tolerance and screening of different cultivars of coconut for drought tolerance using physiological and biochemical triats were continued. The critical period of drought during development of the nut on quality of fruit components was identified. A crop growth model for coconut was developed using physiological, soil and weather parameters as inputs and dry matter production as nuts as the output (UNEP / GEF financially assisted this project). The productivity and cost effectiveness of seasonal production of toddy and nuts in the same coconut palm was evaluated. Vacuum packing and cold storage (13-15 °C) was identified as a suitable treatment for extending shelf life of tender king coconuts up to 38 days for export purposes. Physiological and biochemical aspects, and the effect of different treatments on the recovery of Leaf Scorch Decline (LSD), Tapering Disorder (TD) and Coconut Rapid Decline (CRD)- affected palms were evaluated; FAO and CARP financially assisted this project.

2. RESEARCH PROJECTS

PROJECT 13 : TODDY TAPPING

Experiment 13.6 : Seasonal production of nut and toddy in coconut palms. Bandirippuwa Estate, Lunuwila (2003).

The main objective of this experiment is to use the coconut palm for dual purpose, nut and toddy production for increasing the productivity of coconut plantations. Nevertheless, to use coconut palms for nut production in lean periods, when the coconut price is high and climatic conditions are not suitable for production of toddy (dry), and to use the same palm for toddy production in glut periods, when the coconut price is low and climatic conditions are suitable for production of toddy. The experiment was a completely randomized design with 28 replicates per treatment.

Treatments:

T1- Nut production only

T2- Seasonal nut and toddy production at three monthly intervals
Jan/Mar – allowed inflorescences to open and produce nuts
April/June – tapped the inflorescences for toddy
July/Sep - – allowed inflorescences to open and produce nuts
Oct/Dec - tapped the inflorescences for toddy

In T2 palms, when the tapping was started in April, only the newly opened inflorescence and the successive four bunches were removed. Nevertheless, eight maturing bunches were left on the palm for maturing of nuts. Therefore, those nuts could be collected till December 2003 in T2 palms. The data on number of nuts and volume of toddy produced by T1 and T2 palms were collected (Table 1) and the quality of the products were monitored. The data revealed that seasonal nut and toddy production (T2) increased the annual productivity of coconut plantation compared to production of

coconuts alone (T1). The quality of toddy and coconuts were unaffected by the treatment (data not shown). The experiment will be continued for another one year and the cost and return of the two production systems will be analysed.

Table 1 : *Yield of coconut and toddy of nut producing (T1) and dual- purpose (T2) palms during the first year, 2003.*

	Jan-March		April/June		July/Sep		Oct/Dec	
	No. of nuts	Vol of toddy (L)	No. of nuts	Vol of toddy (L)	No. of nuts	Vol of toddy (L)	No. of nuts	Vol of toddy (L)
T1	31	-	27	-	24	-	28	-
T2	29	-	33	110.4	27	-	26	66.3
Sig.	ns		ns		ns		ns	

C S Ranasinghe, A Jayatillake, N Jayatissa

PROJECT 22 : POST-HARVEST HANDLING OF TENDER KING COCONUTS AND BODIRI FOR QUALITY PRESERVATION.

Experiment 22.3 : Development of a post-harvest technology to improve shelf-life of tender king coconut (1999).

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 improve the existing protocol for enhancing the shelf- life of tender king coconuts up to six weeks. Vacuum packing and cold storage (14-15 °C) was tested as a treatment to enhance shelf-life of tender king coconut up to six weeks.

The first experiment was carried out to identify most suitable packing material to be used in vacuum packing. Black polythene and clear polythene of two gauge sizes were tested. After 36 days the external appearance (skin colour, perianth colour, fungi attack,) and endosperm characters (kernel colour, smell of the nut water and the kernel) of nuts were tested. No difference was found between black polythene packed and clear polythene packed nuts. However, it was decided to use clear polythene in further experiments since the external appearance of nuts can be observed during the storage.

In some European countries and USA, use of fungicides such as Benlate (Benomyl) is banned. Therefore two experiments were conducted with two objectives.

a. To test other disinfection methods with vacuum packing and cold storage (14-15 °C)
b. To test the possibility of storing nuts under vacuum packing and cold storage (14-15 °C) without application of any fungicide.

The second experiment was conducted to test the effectiveness of different surface sterilization methods to prevent fungi attack. The following treatments were tested.

T1	No surface sterilization + vacuum packing + cold storage (14-15 °C)
T2	Application of Benlate on the nut surface (0.6g/l) + vacuum packing + cold storage (14-15 °C)
T3	Application of Teepol on the nut surface (0.1%) + vacuum packing + cold storage (14-15 °C)
T4	Application of NaOCL on the nut surface (10%) + vacuum packing + cold storage (14-15 °C)
T5	Application of CaCl2 + Ca (NO3)2 on the nut surface (0.17 %) + vacuum packing + cold storage (14-15 °C)

After 36 days, Benlate treatment (T2) was found to be the best to use as a fungicide considering the external appearance and kernel and nut water characters of the nuts (Table 2).

Table 2 : *Observations made after 36 days of storage of king coconut at 14-15 °C, under vacuum packing with different surface sterilization methods*

Treatment	No change in skin colour and no shrinking of nut surface (% of nuts)	Free of fungal attack (% of nuts)	Perianth colour turned black (%)	Nut water suitable for consumption (%)	Tender kernel suitable for consumption (%)
Control	67	89	44	89	89
Benlate	89	100	11	89	89
Teepol	100	44	89	22	22
Bleach	33	11	89	22	22
$CaCl_2$	100	11	89	11	11

A parallel experiment was carried out to test whether the growth of fungi on the perianth could be controlled only with vacuum packing and cold storage (14-15 °C), ie, without application of Benlate. It was revealed that the vacuum packing could arrest fungi growth up to about 3 weeks (data not shown). However, it was revealed that for long term storage (36 days) the application of Benlate was essential (Table 3). The experiments are being continued to fine-tune the protocol for achieving 100% infection-free nuts, to meet the exporters' demand.

Table 3 : *The effect of application of Benlate (treated) on different characters of tender king coconuts after 36 days of storage at 14-15°C under vacuum packing. untreated: no Benlate application*

Character	% of nuts	
	Treated (0.6g/l benlate)	**Untreated**
Skin Colour (No change)	100%	100%
Outer skin (No shrink)	100%	100%
Perianth fallen	30%	30%
Perianth colour (turned brown)	20%	100%
Infected perianth	10%	30%
Nut water – suitable for consumption	90%	65%
Kernel – suitable for consumption	90%	65%

PROJECT B-17 : WATER RELATIONS OF THE COCONUT PALM

Experiment B-17.6 : *Field evaluation of embryo-cultured plants screened for drought tolerance (Lenawa Estate, 2003).*

This experiment was conducted to evaluate the field performance of embryo-cultured plants that survived different levels of PEG solutions, using physiological and biochemical parameters.

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, and leaf biochemical parameters (starch, sugar and proline contents) were measured at monthly intervals. The rate of transpiration during wet and dry periods was not different among the treatments (survived PEG level). However, the stomatal diffusive resistance of PEG-screened plants was significantly lower than nursery raised seedlings (control) during the dry period indicating that PEG-screened palms have a mechanism to maintain a better water status compared to control palms (Table 4). The accumulation of starch in leaves during wet and dry periods was also not different among the treatments (Table 5).

Table 4 : *Rate of transpiration and stomatal diffusive resistance of PEG-screened coconut palms and nursery raised seedlings during wet (200 mm / month) and dry periods (50 mm / month) of the year.*

Treatment	Rate of Transpiration ($\mu g\ cm^{-2}\ s^{-1}$)		Stomatal diffusive resistance ($s\ cm^{-1}$)	
	Wet period	Dry period	Wet period	Dry period
3 % PEG	5.39 ±0.21	0.27 ± 0.02	3.61 ± 0.12	116.7 ± 26.5[b]
4 % PEG	5.17 ± 0.15	0.42 ± 0.13	3.29 ± 0.27	109.5 ± 27.0[b]
5 % PEG	5.48 ± 0.84	0.48 ± 0.11	3.93 ±1.19	86.47 ± 20.0[b]
6 % PEG	4.92 ± 0.19	0.47 ± 0.13	3.39 ± 0.15	102.2 ± 25.8[b]
Control	4.99 ± 0.31	0.19 ±0.01	3.46 ± 0.20	187.5 ±13.9[a]
	ns	ns	ns	*

Table 5 : *Leaf starch content of PEG-screened coconut palms and nursery raised seedlings during wet (200 mm / month) and dry periods (50 mm / month) of the year.*

Treatment	Starch content (mg g dwt^{-1})	
	Wet period	**Dry period**
3 % PEG	175.8 ± 12.7	76.0 ± 4.8
4 % PEG	159.4 ± 9.1	74.4 ± 5.9
5 % PEG	166.5 ± 8.85	71.9 ± 2.8
6 % PEG	159.8 ± 5.30	82.4 ± 6.5
Control	154.7 ± 5.51	70.5 ± 3.07
	ns	ns

Mean values and std error (given in the parenthesis), * sig at 0.05, means with different superscript letters are significantly different to each other (Duncan's Multiple Range Test).

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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 will be collected.

1. Canopy temperature (at 7^{th} bunch and 10^{th} bunch levels)
2. Nut surface temperature (topmost nuts of 7^{th} and 10^{th} bunch, exposed to sunlight)
3. Soil temperature (1 m away from the base of the palm, at 30 cm depth, 7-10.00 and 11.00-14.00)
4. Number of female flowers produced and button nut setting
5. Leaf stomatal resistance

C S Ranasinghe, A Nainanayake, R D N Premasiri, L R S Silva

Experiment B-17.6 : *Screening coconut palms (Cocos nucifera L.) for drought tolerance using physiological, biochemical and molecular traits (2001).*

Objective and findings of the preliminary plant house experiment was reported in previous annual reports. It was followed by a field experiment, which was conducted with the objective to screen 40 coconut varieties and germplasm accessions for their drought tolerance using physiological and biochemical traits.

Six, 15-year old adult palms from each germplasm accession were monitored over an eleven-week drought and subsequent 6-week recovery period using gas exchange, water relations, chlorophyll fluorescence (maximum quantum yield of photo system II [F_v/F_m]) and leaf biochemical parameters. The identification of varieties and accessions was performed by (1) analysis of genotype x environment interaction (2) drought susceptibility index (3) cluster analysis and the selected accessions were matched with the water use efficiency estimated by ^{13}C discrimination.

Drought responses of different varieties and accessions were more or less similar except few extreme accessions. Those differences were substantial under early and moderate water deficits (>17% of soil moisture content) but greatly reduced in severe drought conditions. Three accessions *San Ramon Red, San Ramon Green and San Ramon from Clovis estate* showed greater drought tolerance than the other tested accessions with respect to all methods and analytical techniques used. They maintained high leaf water status, high rates of photosynthesis and intrinsic water use efficiency in low moisture conditions (10%) in the top 150 cm of the soil indicating the capacity for higher productivity under such conditions. Although the underlying mechanisms were not precisely identified, it was assumed that those accessions exploited water in deeper soil layers through deep rooting and may possess certain degree of resistance against xylem cavitation. Tall accessions collected from *Namal Watta* and *Palugaswewa* were fairly similar to those of above but were not identified as drought tolerant by all methods used. Tall accessions collected from *Debarayaya* and *Kasagala* retained leaf water status with the progress of the drought, used less water and were drought tolerant in definition and survival oriented but showed low rate of photosynthesis even under moderate drought. Although they showed high drought tolerance they appeared not ideal from a commercial point of view due to their assumed low yielding character but may have importance in extreme areas of coconut cultivation and areas with frequent droughts. *D x T* possessed high potential for photosynthesis and high yield under favourable or moderate drought conditions and quickly recovered after re-wetting. This potential was proved by long term yield data of field trials conducted by G&PB division. *Dwarf Brown* had higher potential for the photosynthesis than all other dwarf varieties under favourable or moderate drought conditions but not at severe droughts. It would be worthwhile in developing and testing hybrids using *Dwarf Brown* as a parent along with a suitable tall variety.

A Nainanayake

PROJECT : DEVELOPMENT OF THE NUT

Experiment B- : *Effect of environmental variations on the development of coconut fruit (BE, 2003).*

The objective of this study is to determine the critical stage of drought for development of fruit components. Size of the nuts (length at polar and equatorial directions), weight of the nut and husk, thickness and weight of kernel, thickness and weight of shell and volume of nut water were monitored monthly. From the final 12 months period of nut development (**0 month**: fertilized female flower, **12 month**: mature nut), the most critical months of drought that reduces the size of the nut, weight of husk, weight of husked nut, weight and thickness of kernel, weight of shell and volume of nut water were determined. The relationship between number of dry days during the particular critical month and variation in quantity of fruit components is shown below (Figure 1 and Table 6).

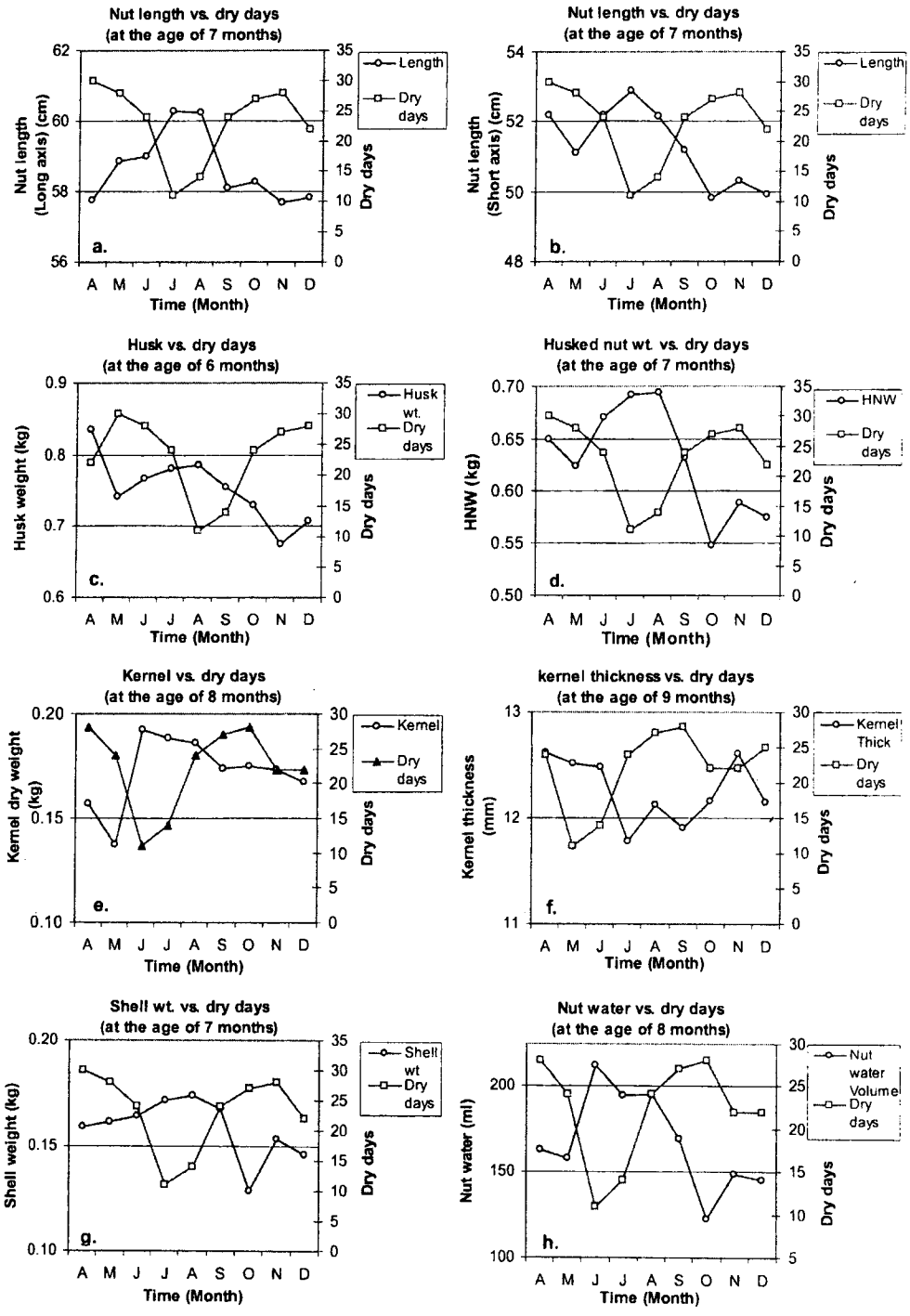

Fig. 1. : ***Changes in (a) nut length (cm) on long axis (b) on short axis (c) Husk wt. (kg) (d) husked nut wt. (kg) (e) Kernel dry wt. (kg) (f) Kernel thickness (mm) (g) Shell wt. (kg) and (h) Volume of nut water (ml) in relation to the number of dry days per month over a period of 9 months (April to December).***

Table 6 : *Most critical months of the year for reduction in fruit components and final yield*

Fruit component / final yield	Most critical month of drought from final 12 months period (0 month: fertilized female flower, 12 month: mature nut)
Size of the nut (long axis, short axis)	7th month
Weight of husk	6th month
Weight of husked nut	7th month
Weight of kernel	8th month
Thickness of kernel	9th month
Weight of shell	7th month
Volume of nut water	8th month

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PROJECT : DEVELOPMENT OF CROP-GROWTH MODELS FOR COCONUT

Experiment : ***The effect of CO_2 increase in the atmosphere on growth and production of coconut.***

The experiment was conducted with a view to determine the effect of atmospheric CO_2 elevation on leaf production rate, leaf area development, growth of root system, gas exchange rates and assimilate partitioning pattern in coconut seedlings. These relationships will be used for developing crop models for coconut. Two open top chambers (4.3 m diameter x 2.8 m height, covered with UV treated polythene) were constructed at Bandirippuwa Estate, Coconut Research Institute and coconut seedlings were exposed to either elevated CO_2 (550-600 ppm) or ambient CO_2 (350-360 ppm).

Net assimilation rate of the coconut seedlings exposed to elevated CO_2 was increased by 20-30% compared to control (data not shown). ***There was an increase in the shoot and root development by 8% and 25%, respectively, with CO_2 enhancement*** (Table 7).

Table 7 : *Variation in leaf production rate, leaf area development and weight of roots, shoot and leaves under ambient (350-360 ppm, A- CO_2) and elevated (550-600 ppm E- CO_2) CO_2 concentrations.*

Treatment	Leaf production rate No / 6 months	Leaf area development cm^2 / 6 months	Root weight (g)		Shoot wt (g)		Leaf wt (g)	
			Fresh	Dry	Fresh	Dry	Fresh	Dry
A- CO_2	4.36	4688.8	138.1	34.2	321.6	60.4	263.7	78.3
E- CO_2	4.58	4716.3	205.4	42.9	334.0	64.8	290.6	86.6
Increase	5%	0.6%	48%	25	4	7	10	11

C S Ranasinghe, L R S Silva

Compiling available data of different Agro climatic Zones, Agro Ecological Regions, land suitability classes and soil series for developing crop growth models:

Data on physical and chemical properties of coconut growing soils and physiological parameters of coconut palm were collected from relevant sources.

Soil attributes:

The following soil physical parameters with respect to five land suitability classes (S1, S2, S3, S4 and S5) were collected.

- Bulk density
- Rooting depth
- Water retention capacity
- Duration of water retention
- Macro and micro porosity %

The following soil chemical parameters with respect to five land suitability classes (S1, S2, S3, S4 and S5) were collected.

- Total Nitrogen content
- Soil pH

Physiological parameters:

- The mean rate of evaporation of coconut plantations over the year in three Agro-Climatic Zones (ACZ) was collected.
- The rates of transpiration and photosynthesis (net assimilation) of coconut palms during wet (with adequate soil moisture) and dry periods (with soil moisture stress) were also collected for developing crop models.
- Pattern of biomass increase in developing coconuts from fertilized female flower (1M) to mature coconut (12M)

Development of crop models:

In collaboration with IARI, a basic crop growth model for coconut was developed using **crop physiological data** (yield, crop phenology, radiation use efficiency, dry matter increase and partitioning, leaf area index, yield reduction in response to rain fall, temperature and nutrient stress, and impacts of CO_2 elevation), **weather data** (Maximum and Minimum temperature, rainfall and sunshine hours) and **soil data** (N, P, K, Mg (applied and optimum levels), depth of soil in different land suitability classes (S1-S5) and organic carbon levels) as inputs. The model calculates the dry matter production (as coconuts) at monthly basis, as the output. This model needs to be upgraded by adding other physiological and soil parameters related to the growth of coconut palm. Further, the basic model was developed for Bandirippuwa Estate/ IL1 and it can be extended to other Agro Ecological regions by modifying input data and stress effects. These models can be used at field, farm, regional and national levels for estimation of potential yields, yield gaps, principal causes and their contribution for yield gaps, yield forecasting and optimizing management strategies like irrigation and mulching. Furthermore, these models will be linked with the SRILANKACLIM and be used in the studies on impact assessment of climatic variability and climate change on coconut. Therefore, the final models can be used as decision aids for stakeholders such as scientists, farmers and extension workers, industry, regional and national planners and environmentalists.

C S Ranasinghe

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 (Leaf Area

Index) 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.

Nine months after planting, the leaf water potential, rate of photosynthesis and leaf area development of the seedlings were almost similar in different land suitability classes. However, transpiration rate was significantly lower and stomatal diffusive resistance was significantly higher in S1 grown seedlings (Table 8). The reason may be that this soil belongs to Madampe series that has the texture of course loamy sandy soil, and is moderately well drained. The surface drying of such soils may be comparatively higher than the other three soils. Since the root system of these seedling are not yet developed to extract water from the deep layers, and due to the nature of sandy texture, drying of soils in the upper layer is higher in S1 creating a soil moisture stress condition for seedlings.

Table 8: *Leaf Water Potential (LWP), Rate of transpiration (Tr), Stomatal Diffusive Resistance (rs), Rate of photosynthesis (Photo) and total leaf area of seedlings grown in suitability class 1,2,3 and 4.*

LSC	LWP (MPa)	Tr ($\mu g\ cm^{-2}\ s^{-1}$)	Rs ($s\ cm^{-1}$)	Photo ($\mu mol\ m^{-2}\ s^{-1}$)	Leaf Area (cm^2)
S1	-0.97	1.4^a	10.6^a	6.92	58.95
S2	-0.99	4.8^b	3.96^b	7.82	62.38
S3	-1.09	4.4^{ac}	4.73^b	7.01	59.29
S4	-1.09	4.3^c	4.48^b	6.99	61.31
Sig.	ns	***	***	ns	ns

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). There was no difference in the physiological parameters of seedlings measured after nine months of planting (Table 9).

Table 9: *Leaf Water Potential (LWP), Rate of transpiration (Tr), Stomatal Diffusive Resistance (rs) and Rate of photosynthesis (Photo) of seedlings grown in under low and high light intensity.*

Light level	LWP (MPa)	Tr ($\mu g\ cm^{-2}\ s^{-1}$)	Rs ($s\ cm^{-1}$)	Photo ($\mu mol\ m^{-2}\ s^{-1}$)
85-90%	-1.0	4.8	4.0	7.82
40-50%	-1.0	4.6	4.0	7.09
Sig.	ns	ns	ns	ns

Experiment : The effect of different levels of micro nutrients on the growth of coconut seedlings; hydroponic experiment (Bandirippuwa Estate, 2003)

The objective of this study was to evaluate the effect of micro-nutrient deficiency on growth and physiological performance of coconut seedlings. As a preliminary investigation, the most suitable age of amputated seedling suitable for hydroponic experiment was tested and six to seven month- old

amputated seedlings were found to be the best stage. When amputated seedlings were grown in the nutrient solution, it takes about 3-4 weeks to develop new roots. The experiment will be continued and the treatments will be nutrient solutions with and without major micro nutrients, Zn and Cu.

W S Madurapperuma, R D N Premasiri, A Jayatilake

PROJECT 24: LEAF SCORCH DECLINE (LSD) OF COCONUT PALM

Experiment: Effect of leaf spraying of macro and micro- nutrients on 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 and Walpita Research Stations. Mild and moderate-LSD affected palms and healthy palms were selected for the experiment. Total nutrient solution including macro and micronutrients were sprayed to the canopy at three monthly intervals. Before and after spraying, the 14th frond was analysed to determine the improvement of macro and micro nutrient levels. Samples were collected from 9th frond to analyse chlorophyll content. Monthly observations of the total number of fronds and number of scorching fronds were done.

The initial leaf chlorophyll content did not show significant difference between healthy and LSD-affected palms. However, with nutrient spraying the total chlorophyll content of all the palms was increased indicating re-greening of the canopy. Furthermore, after second spraying of nutrients, the total chlorophyll content in healthy and mild-LSD palms was significantly higher than moderate-LSD palms indicating different potentials of regreening of the leaf canopy between mild- and moderate-LSD palms (Table 10).

Table 10: *Variation in total chlorophyll content (mg / g fresh wt) with nutrient spraying (1st in June and 2nd in September) in healthy, mild-LSD and moderate-LSD affected palms at Walpita and Bandirippuwa Research Stations. Initial: pre-treatment in March.*

Stage	Pre-tretment	After 1st Spraying	After 2nd spraying	Pre-tretment	After 1st Spraying	After 2nd spraying
		Walpita Estate			Bandiruppuwa Estate	
Healthy	2.65	3.31	3.48^{a}	2.55	3.09^{a}	3.48^{a}
Mild-LSD	2.48	3.17	3.39^{a}	2.48	3.05^{a}	3.39^{a}
Mod-LSD	2.28	2.76	2.86^{b}	2.54	2.66^{b}	2.86^{b}
Sig.	NS	NS	*	NS	**	*

However, the total number of fronds or ratio between scorched to total number of fronds was not improved during the first six months (June – December) with two nutrient sprayings. The analysis of leaf nutrients six months after treatment application is in progress (Tables 11 and 12).

Table 11: *The variation in total number of fronds of healthy, mild-LSD and moderate-LSD affected palms with time at Bandirippuwa Research Stations. Pre-treatment in March, 1st and 2nd nutrient sprayings in June and September, respectively.*

Stage	Mar	June	Aug	Sep	Nov	Dec
Healthy	33.3	31.9	33.0^{a}	32.1	31.4	32.3
Mild-LSD	30.3	29.2	28.6^{b}	28.8	28.9	29.3
Mod-LSD	28.1	27	26.9^{b}	26.2	26.5	26.5
Sig.	NS	NS	*	NS	NS	NS

Table 12: *The variation in the ratio between number of scorching fronds to total number of fronds of healthy, mild-LSD and moderate-LSD affected palms with time at Bandirippuwa Research Stations. pre-treatment in March, 1st and 2nd nutrient sprayings in June and September, respectively*

Stage	Mar	June	Aug	Sep	Oct	Nov	Dec
Healthy	0^a	0^a	0^a	0^a	0^a	0^a	0^a
Mild-LSD	0.50^b	0.44^b	0.47^b	0.42^b	0.49^b	0.44^b	0.43^b
Mod-LSD	0.52^b	0.51^b	0.48^b	0.46^b	0.50^b	0.45^b	0.55c
Sig.	*	*	*	*	*	*	*

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5. TRAINING AND EXTENSION ACTIVITIES

Research and technical staff participated as resource personnel in many training programmes for Agriculture teachers and students, Agriculture extension officers and Coconut Development Officers.

6. ACKNOWLEDGEMENT

The co-operation and assistance extended by the staff of the Plant Physiology Division in conducting experiments, data collection and compiling this report is gratefully acknowledged.

REPORT OF THE EXTENSION SERVICES DIVISION
Head - P A H Nimal Appuhamy, MSc

1. GENERAL

The Division implemented various programmes and activities to introduce and promote the adoption of new technologies with effective interaction among stakeholders, researches, and extension personnel of the coconut cultivation Board (CCB). The number of stakeholders who received various services under these programmes has shown a significant increase during the year.

During the first quarter of the year, the divisional staff heavily involved in the establishment of field demonstrations in various parts of the country to promote the use of polythene bags with sulpher to control coconut mite. These demonstrations were conducted in collaboration with CCB and the Crop Protection Division of CRI.

The Division also coordinated the linkage planning sessions and workshops of the Institute as a part of the project implemented by the International Services of National Agricultural Research (ISNAR) funded by ADB.

2 OTHER ACTIVITIES

2.1. Mrs. H D N H Fonseka, Assistant Extension Officer, continued the postgraduate studies at the Postgraduate Institute of Agriculture, Peradeniya.

2.2 Mr. G Gunawardene, Extension Officer, commenced his postgraduate studies at the Agricultural University, Rajasthan, India from August.

2.3 Mr. P A H Nimal Appuhamy, Head, Extension Services Division and Mr. Sarath Idirisinghe, Extension Officer, attended the regional workshop of ISNAR held at Hanoi, Vietnam from 15 to 21 June

3. ESTATE AND FARM DEVELOPMENT SERVICES

3.1 Persuasive Extension Programme (PEP)

The Persuasive Extension Progamme (PEP) implemented by the Division to promote the adoption of new technologies in the coconut sector could not be continued as scheduled due to lack of funds. In the year under review only 18 estates were inspected covering on extent of 755 acres. Estate development plans prepared based on the potential of these estates was supplied to the owners.

3. 2 Technical Support Services

Several discussions were held with the management of CCB regarding the activities of the Extension Services Division and CCB. Consequently it was agreed to establish effective linkages with the extension personnel and other stakeholders by the Coconut Research Institute. These linkages were essential to acquire information of the sector problems, technology needs, constraints in technology dissemination and impact achieved at the field level. These provide inputs for the formulation of CRI research agenda, which generates technology that will be more acceptable to end-users.

The objective of the information and technology transfer activities of CRI were identified as follows

1. Two way channeling of technology and information to/ from stakeholders
2. Acquire information from stakeholders about their technology needs and production problems.

3. Evaluation of the relevance and impact of CRI technologies
4. Participation of stakeholders in CRI technology development and transfer programme planning and review tasks.

4. TRAINING PR0GRAMMES

4.1 One Day Training Programme

This is the most popular programme of the Institute conducted for the benefit of coconut growers. One day training programme series conducted by the Division includes seven individual programmes on specific technical areas in coconut cultivation and estate management. The improvement of technical knowledge and skills of coconut growers and the establishment of research and grower linkages are the main objectives of this series. The special feature of this programme is that research workers of various disciplines have direct interaction with coconut growers and the management staff of coconut estates. This kind of grower interactive activities is important in understanding field problems by the research personnel. The popularity of this training series increases year by year and the highest participation was recorded in the year under review. The details of the series of programmes conducted by the Division are given below.

ProNo.	Date	Venue	Subject Area	No. of Partici.
01	23 May	Isolated Seed Garden, Ambakelle	Replanting of Coconut	148
02	27 June	Ratmalagara Estate	Soil and Moisture Conservation	137
03	18 July	Bandirippuwa Estate	Fertilizer application	168
04	22 August	Walpita Estate	Intercropping under coconut	171
05	19 September	Bandirippuwa Estate	Pest and Diseases of coconut	144
06	17 October	Ratmalagara Estate	Rehabilitation of low yield in coconut estates	160
07	22 November	Bandirippuwa Estate	Estate and Labour Management	128
Total number of participants				1056

Those who attended the above full series of programmes were issued with certificates.

4.2 Other Training Programmes

4.2.1. Several field training and demonstrations were conducted for coconut growers on sulpher bagging for coconut mite control in the Mannar region. These demonstrations were conducted in three places in Mannar and one place at Murungan. From 08 to 10 January.

4.2.2. A full day training programme was conducted for Members of the North-Western Provincial Council on 21 January

4.2.3. A training progrmme was conducted for a group of undergraduates from the University of Jaffna on 20 January.

4.2.4. The Institute conducted the coconut module of the Plantation Diploma Course organized by the National Institute of the Plantation Management (NIPM) from 28 May to 01 June.

4.2.5. A full day training progrmme was conducted for a group of media officers of the Farmer Broadcasting Service of the Department of Agriculture on 03 July

4.2.6. A training programme was conducted for a group of Agricultural Officers from Pallewela, Pasyala on 29 June.

4.2.7. A group of coconut growers participated a full day training conducted by the Institute on 19 November.

4.2.8. Three training programmes were conducted on intercropping under coconut, bee keeping in coconut lands and toddy tapping for members of the Poverty Alleviation Project coordinated by the Agronomy Division.

5. TECHNOLOGY TRANSFER AND EDUCATIONAL PROGRAMMES

5.1 The Division conducted an educational programme for a group of diploma students from Angunakotapallessa on 07 November.

5.2 An educational programme was conducted for agriculture diploma students from Kundasale on 18 November.

5.3. The Division conducted an educational programme for agriculture diploma students from Naiwala on 28 August.

5.4. The members of the Kalutara District Agricultural Committee visited the institute on 30 July for an educational and familiarization programme.

5.5. The division conducted a series of technology transfer programmes for the extension personnel of the Coconut Cultivation Board. The first progrmme was conducted at CRI on 13 and 14 March for the field extension personnel from Marawila, Kuliyapitiya, Kurunegala and Kegalle regions. The second programme was conducted for officers from Gampaha, Ratnapura, Matale and Galle regions on 27 and 28 March. The third technology transfer progrmme was conducted for regional extension personnel from Monoragala, Polonnaruwa, Hambantota, Anuradapura, Ampara and Baticolo on 01 and 02 April

6. SEMINARS, FIELD DAYS AND WORKSHOPS

6.1. A seminar was conducted on Reaching the Production Target of Three Billion Nuts for coconut growers at the Hector Kobbekaduwa Agrarian Research and Training Institute on 07 June.

6.2 A seminar was conducted for coconut growers at the CRI Auditorium on the Improvement of Productivity of Coconut Lands on 30 August.

6.3 A seminar on coconut irrigation was conducted at " Savsiripaya" Colombo for those who are interested in irrigating their coconut lands. CRI scientists and outside experts in the irrigation field gave presentations at the seminar held on 07 November.

6.4 The Division conducted several field days on mite control activities in the Mannar District from 08 to 10 January. Several field demonstrations were also conducted by the staff of the Division on mite control with sulpher bagging.

7. EDUCATIONAL PROGRAMME

7.1 The Division provided necessary technical information and guidance to GCE (O/L) and GCE (A/L) students to complete their study projects on coconut cultivation and management. During the year the divisional staff provided assistance to 42 school projects for students from different coconut growing areas.

7.2. The Division conducted special educational programmes for school children and students from other educational institutions. These educational programmes were arranged based on their educational needs. During the year 7600 school children attended these

programmes from 68 schools and 170 students and undergraduates from Agricultural Schools and Universities respectively.

8. ADVISORY AND CONSULTANCY ACTIVITIES

8.1 Advisory Field Visits

On the request of coconut growers and extension staff of CCB field visits were made to provide technical advice and guidance in respect of their field problems. During the year, the staff of the Division made 38 advisory and consultancy visits.

8.2 Office Call for Advice

A significant increase in the number of stakeholders visited the Division for technical advice was observed during the year. Their major problems were pest damages by Red Weevil, Black Beetle, Coconut Mite and declining of nut production. Over five hundred coconut growers visited the Division seeking technical support services during the year.

8.3 Technical Advise on Telephone

Coconut growers have an opportunity to obtain technical advice for their field problems through a direct telephone line dedicated for this purpose. Around 1500 stakeholders received this service from the divisional staff during the year.

8.4 Advice through mail

The division received a large number of advisory correspondences from different parts of the country. These letters were replied promptly even with relevant literature.

9. PRINTING AND PUBLICATIONS

The Printing Section of the Division under took major printing requirements of the Institute. During the year under review the Division completed over hundred printing jobs of the Institute. The Division printed and issued the following publications

1. CRI Annual Report 2002
2. Short CRI Annual Report 2002
3. CRI Annual Report 2002 in three languages for the parliament
4. CRI Newsletter Vol. 4
5. Seven booklets issued to the participants of the One Day Training Programme conducted by the Division.
6. The report on CRI Strategic Planning prepared by ISNAR.
7. Twenty advisory circulars in Sinhala, English and Tamil

10. EXHIBITIONS AND AUDIO VISUAL MATERIALS

As an effective mode of transferring technology to stakeholders the Division participated in following exhibitions during the year.

1. The school exhibition at the Martin the Poros School at Wennappuwa on 21 March.
2. Technololanka 2003 exhibition held at Katugasthota School, Kandy from 03 to 12 August.
3. Regaining Sri Lanka Agricultural Exhibition held at Labuduwa, Galle from 09 to 16 August.
4. Agricultural exhibition held at the Holy Family Convent, Bambalapitiya on 08 September
5. Agricultural exhibition at the Thimbirigaskatuwa Maha Vidyalaya Negombo on 25 November.
6. Nawa Dekma industrial and agricultural exhibitions held in Colombo from 12 to 22 December.

11. PUBLICITY AND MEDIA PROGRAMMES

Mass Medias were effectively used to educate stakeholders on new technologies available. In these programmes more emphasis was given on new measures recommended to contorl coconut mite and Red Weevil pests. Two video documentaries were produced on these pest control measures. The staff of the Institute participated to live television programme "Kamatha" in two occasions on pest control activities. Several TV news items were also organized and telecast highlighting important areas on crop management. A series of newspaper articles is also published on important issues in the coconut cultivation sector. The divisional staff also participated several radio discussions.

A series of new display boards were introduced to highlight the use of CRIC 65 as the recommended planting material for home gardens and management practices of coconut. These boards were mainly used for the CRI exhibition stalls in various parts of the country.

ANNUAL REPORT OF THE LIBRARY 2003
Actg. Librarian - P A H Nimal Appuhamy, MSc.

1. GENERAL

The library functioned smoothly, throughout the year. Information needs of the institutes' staff and outside clients were satisfactorily fulfilled using resources within and outside the library.

2. ACQUISITIONS

Twenty (20) new books were accessed to the library during the year and the stock recorded 5688 as at 31.12.2003.

Thirty three (33) periodical titles and Six (6) Annual reports were received during the year. Seven (7) titles were received on subscription and the others were received either on complimentary basis or exchange.

3. SERVICES

Reference, lending, interlibrary loan (ILL) services were provided regularly to the research staff and ten (10) requests for literature searches from the institutes' staff and outsiders. Twenty (20) literature searches were made on the coconut database to cater to the information needs of the staff. Of these searches were made on behalf of the CRI staff.

Resource sharing activities were continued satisfactorily with other AGRINET libraries throughout the year.

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 in 4 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 (Estates)
H A J Gunathilaka, Ph D

1. SUMMARY.

The following Research Centres and Genetic Resource Centres were maintained under the purview of the Estate Management Division.

1. Bandirippuwa Main Research Centre, Lunuwila.
2. Ratmalagara Research Centre, Panirendawa.
3. Poththukkulama Research Centre, Pallama.
4. Pallama Genetic Resource Centre, Pallama.
5. Walpita Research Centre, Walpita.
6. Ambakelle Genetic Resource Centre, Ambakelle.
7. Makandura Genetic Resource Centre, Gonawila.
8. Maduruoya Genetic Resource Centre, Bogaswewa.
9. Dunkannawa Genetic Research Centre, Nattandiya.

All units were maintained in order and the CRI Estates and seed garden were renamed (as above).

All the above seed gardens and Research Centres covering 800.6 ha were maintained satisfactorily. Maduruoya and Ambakelle seed gardens continued to supply a majority of seed nuts requirement of the country. There is a 49% increase of seed nut supply compared to the year 2002. Pallama seed garden is yet under the development and may need more years to supply seed nuts. The coconut yields in all estates was 4,211,391 nuts, which is an increase by 1,261,431 nuts or 42% compared to the previous year. Equally distributed rain fall throughout the previously year and this year contributed to this satisfactory increase.

The nine estates have a total of 75,305 bearing palms with 4,224 partially banning palms and 17,937 young palms and seedlings.

In order to improve the profitability, intercropping and livestock were continued and the total sundry income was Rs. 2,483,120.85

2. PERFORMANCE OF INDIVIDUAL UNITS

2.1. Bandirippuwa Main Research Centre, Lunuwila

Superintendent	:	**Mr G.B.A.Wijesekara**
District	:	**Puttlam**
Agro-ecological Zone	:	**Wet Intermediate**
Extent	:	**148.1 ha**

Rainfall :

The total rainfall was 1360 mm (Table 2) and 94 wet days, which is a decrease by 23.57% and 13% respectively, when compared to the last year. The rainfall distribution was fair.

Nut Yield :

Increased by 69.15% over the previous year.

Livestock :

Herd strength was as follows.

Heifers	-	23
Stud bulls	-	02
Male calves	-	18
Female calves	-	10
		53

Milk production and sale :

Total Milk production	=	9,189 Lit
Total income from milk	=	Rs.78,439.00

Cost of production (COP) - Rs.9,020 per 1000 nuts.

Net Sale Average (NSA) - Rs.8,130 per 1000 nuts.

Sundry Income :

By selling fruits, vegetables, toddy, treacle and milk Rs. 1,070,273.00 was collected and Rs. 375,765.00 was collected by selling coconut seedlings, coconut timber, animals etc.

Income by sale of coconut and allied products

Coconuts	-	Rs. 3,368,336
Copra	-	Rs. 169,522
Other	-	Rs. 663,514
Total	-	Rs. 4,201,372

2.2 Rathmalagara Research Centre, 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 1,363.3 mm. and 108 wet days which is a decrease by 24.3% and 11.5% respectively when compared to the last year. The rainfall distribution was fair.

Nut Yield :

Increased by 50.56% over the previous year.

Livestock :

Herd strength was as follows.

Heifers	-	36
Calves	-	10
Cows	-	24
Cart bulls	-	01
		71

Sundry Income :

An income of Rs.265,143.12 was collected by selling milk, vegetable, animals, coconut, unproductive palm and other trees.

Cost of production (COP) - Rs.9,710 for 1000 nuts.

Net Sale Average (NSA) - Rs. 10,750.32 for 1000 nuts.

2.3 Ambakelle Genetic Resources Centre, Pallama

Superintendent	:	Mr.W.M. Upali Rathnayaka
District	:	Puttlam
Agro-ecological Zone	:	Intermediate Dry Zone
Extent	:	456.20 ha

Rainfall :

The total rainfall was 1,211.4 mm and 94 wet days.

Nut Yield :

Increased by 133.73% over the last year. (Table- 1)

Livestock :

Herd strength was as follows.

Stud bulls	-	01
Cows	-	12
Calves (Female)	-	14
Calves (Male)	-	09
Cart bulls	-	01
Total	-	37

Sundry Income :

Selling animals, firewood, curd, banana and leasing cashew trees collected an income of Rs. 224,056.40.

Sale of coconuts and allied products :

Coconut	=	Rs.	15,137,696.54
Seedlings	=	Rs.	515,776.00
Copra	=	Rs.	1,781,543.03
Total	=	Rs.	17,435,015.57

Cost of production (COP) - Rs. 4181 for 1000 nuts.

Net Sale Average (NSA) - Rs. 11,410.49 for 1000 nuts.

2.4 Maduruoya Genetic Resources Centre, Bogaswewa

Superintendent	:	Mr. Harald Upali
District	:	Polonnaruwa
Agro-ecological Zone	:	Dry Zone
Extent	:	85 ha

Rainfall :

Total rainfall received was 1,760 mm and 89 wet days which is a decrease by 6.21% and a 7.3% respectively when compared to the last year. The rainfall distribution was good.

Net Yield :

Decreased by 10.30% over the previous year.

Livestock :

Herd strength was a follows.

a. Buffaloes : -	Male buffaloes	-	06
	Female buffaloes	-	04
	Total	-	10

Sundry Income:

Rs. 39,088.50 was collected of selling fruit, banana, melon shells and firewood.

Fencing :

1000 m of new fencing was done in one round.

Cost of production (COP) - Rs.6,970 for 1000 nuts

Net Sale Average (NSA) - Rs. 8,350 for 1000 nuts.

Income by sale of coconuts and allied products :

Coconut	=	Rs. 2,522,084.77
Copra	=	Rs. 66,684.75
Seedlings	=	Rs. 23,140.00
Total		Rs. 2,611,909.52

2.5 Poththukulama Research Centre, 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 1261.31 mm and 86 wet days which is a decrease by 10.8% and 4.5% respectively when compared to the last year.

Nut Yield :

Increased by 56.23% over the previous year.

Livestock :

Herd strength was as follows.

Cows	-	17
Bulls	-	06
Goats (male)	-	27
Goats (female)	-	68
Buffaloes	-	07
Total	-	125

Sundry Income :

Rs. 101,012.40 was collected by selling animals, coconut palm etc.

Cost of production (COP) - Rs. 5,665.17 for 1000 nuts.

Net Sale Average (NSA) - Rs. 8,410/- per 1000 nuts

Fencing: 350 m were used for old fence repair.

Income by sale of coconuts and allied products.

Coconut	=	Rs. 15,638,411.97
Copra	=	Rs. 96,259.87
Total		Rs. 15,734,671.84

2.6 Pallama Genetic Resources centre, Pallama

Superintendent	:	Mr.W.M.U.R.Rathnayaka
District	:	Kurunegala
Agro-ecological Zone	:	Dry Zone
Extent	:	260 ha

Rainfall :

Total rainfall was 1,325.6 mm and 77 wet days which is a decrease by 7% and no change in the number of wet days when compared to last year.

Nut Yield :

Increased by 78% over the previous year.

Livestock :

Herd strength was as follows.

Cows	-	08
Calves (male)	-	02
Calves (female)	-	20
Heifers	-	02
Stud bulls	-	01
Total		33

Sundry Income :

Rs. 243,114.06 was collected of selling animals, milk, unproductive coconut palms & other tree etc.

Income by sale of coconuts and allied products:

Coconuts	=	Rs. 3,121,807
Copra	=	Rs. 100,124
Total		Rs. 3,221,931

Cost of production (COP) - Rs. For 1000 nuts.

Net Sale Average (NSA) - Rs. For 1000 nuts.

2.7 Makandura Genetic Resources Centre, Gonawila

Superintendent	:	Mr.A.N. Ekneligoda
District	:	Kurunegala
Agro-ecological Zone	:	Wet Intermediate
Extent	:	50.20 ha

Rainfall :

The total rainfall was 1171.2 and 78 wet days. (From January to September)
Nut Yield:

Increased by 66.92 over the last year.

Livestock :

Herd strength was as follows.

Cows	-	10
Stud bull	-	05
Buffaloes (male)	-	15
Buffaloes (female)	-	05
Calves (male)	-	
Calves (female)	-	
Total	-	

Sundry Income :

Rs. 112,832 was collected by selling fruit, milk, animals etc..

Fencing :

9,600 m of old fencing was repaired.

Cost of production (COP) - Rs. 5,140 for 1000 nuts.

Net Sale Average (NSA) - Rs. 9,370 for 1000 nuts.

2.8 Walpita Research Sub Station, Walpita

Officer In Charge	:	Mr.I. A. Nimal Hemasiri
District	:	Gampaha
Agro-ecological Zone	:	Wet Intermediate
Extent	:	17.8 ha

Rainfall :

Total rainfall was 2217.4 mm and 99 wet days which is an increase by 0.04% and a decrease by 18.2% respectively, when compared to the last year.

Nut Yield :

Decreased by 2.00% over the last year

Livestock :

Herd strength was as follows.

Cows	-	02
Bulls	-	01
Buffaloes	-	01
Total	-	04

Sundry Income :

Rs.14000.78 was collected by selling pineapples, banana, ginger, manioc, pepper, cocoa, cinnamon etc.

Income by selling coconuts and allied products.

Coconuts	=	Rs. 1,071,712.93
Copra	=	Rs. 22,336.00
Total	=	Rs. 1,094,048.93
		==========

Cost of production (COP) - Rs.8, 100 for 1000 nuts.

Net Sale Average (NSA) - Rs. 8,610 for 1000 nuts.

2.9 Dankotuwa Research Centre, Nattandiya

Officer in Charge	:	Mr. Newton Gamage
District	:	Puttalam
Agro-ecological Zone	:	Intermediate Wet Zone
Extent	:	10.4 ha

Rainfall :

The total rainfall was 1,145.5 mm and 45 wet days, which is a decrease by 26.6% & 34.8% respectively when compared to last year.

Nut Yield :

Increased by 45% over the previous year.

Sundry Income :

Rs. 2,290.00 was collected by selling intercrops.

Income by coconut and allied products.

Rs. Coconuts = Rs. 114,718.30

Cost of Production (COP) - Rs. For 1000 nuts.

Net Sale Average (NSA) - Rs. For 1000 nuts

Table 1 : *Total Nut Production (1999-2003) and Percentage Change in 2002 production over 2001.*

Estate	1999	2000	2001	2002	2003	% Change
Bandirippuwa Main Research Centre	556,185	758,487	752,452	319,296	540,072	69.15
Ambakelle Genetic Resource Centre	1,473,458	1,396,565	1,475,761	662,854	1,549,281	133.75
Poththukulama Research Centre	816,737	834,061	777,906	440,222	687,763	56.23
Ratmalagara Research Centre	526,947	658,968	760,946	405,305	533,073	50.56
Pallama Genetic Resource Centre	592,661	640,343	680,946	354,060	509,925	78.18
Makandura Genetic Resource Centre	451,152	644,016	636,889	286,187	477,697	66.92
Maduruoya Research Centre	210,234	297,328	346,507	344,623	309,106	(-10.30)
Walpita Research Centre	142,546	188,958	160,124	129,473	126,927	(-02.0)
Dunkannawa Research Centre	-	-	-	7,940	17,614	45%
Total	4,769920	5,418,716	5,591,431	2,949,960	4,211,391	

Table 2 : *Rain fall (mm) and Number of wet days- (2002-2003)*

Month	Bandirippuwa Main Research Centre		Ambakelle Genetic Resource Centre		Rathmalagara Research Centre		Poththukulama Research Centre	
	2002	2003	2002	2003	2002	2003	2002	2003
January	5.2(02)	54.2(06)	9.5(03)	46.7(08)	12.4(02)	112.2(09)	-	44(07)
February	23.2(04)	02(01)	84.0(03)	19.6(04)	25.1(03)	27.8(03)	56.4(02)	23(04)
March	165.0(06)	77(09)	23.6(03)	161.3(10)	80.9(05)	177.8(09)	20.0(04)	168.15(09)
April	258.5(14)	146(10)	406.8(21)	178.6(10)	330.0(20)	125.8(11)	460.4(23)	214.15(07)
May	240.7(15)	168.5(08)	162.4(13)	71(07)	159.7(18)	138.3(04)	137.1(09)	55.5(04)
June	87.8(08)	214.9(11)	70.8(07)	162(13)	73.8(09)	264.3(16)	54.6(06)	148.2(11)
July	04.0(01)	69.8(09)	-	94.9(09)	4.8(02)	48(11)	-	122.7(09)
August	48.7(04)	17.1(04)	10.1(03)	14.5(01)	9.6(03)	5.4(02)	10.0(02)	7.5(02)
September	34.7(06)	81.9(04)	71.3(03)	23.5(03)	54.7(06)	26.5(05)	20.2(03)	24.2(06)
October	606.1(24)	293(17)	453.3(17)	217.4(13)	445.5(23)	251.9(21)	405.7(17)	178.19(15)
November	213.6(17)	234(15)	220.5(16)	199.6(12)	456.3(18)	168.7(15)	283.5(15)	252.9(11)
December	91.3(07)	-	132.0(13)	22.3(04)	147.3(13)	16.6(02)	144(09)	23(01)
Total	1779.4(108)	1360.5(94)	1644.3(102)	1211.4(94)	1800.4(122)	1363.3(108)	1591.9(90)	1261.31(86)

Continued Table - 02

Month	Pallama Genetic Resource Centre		Makandura Genetic Resource Centre		Maduruoya Genetic Resource Centre		Walpita Research Centre		Dunkannawa Genetic Resource Centre	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
January	5.0(01)	38.4(03)	19.6(02)	90.4(06)	215(11)	358(12)	23.0(02)	164(05)	-	59(03)
February	28.0(02)	20.1(03)	10.6(02)	10.6(01)	138.5(06)	257.2(09)	31.6(03)	21(01)	-	-
March	30.5(03)	189.8(07)	153.2(06)	191.1(11)	23.0(03)	88.9(07)	109.8(06)	265.2(13)	134.9(05)	118.6(05)
April	497.0(20)	215.3(10)	576.0(18)	196.4(13)	175.2(18)	63.7(06)	514.8(20)	284.2(09)	370.5(16)	142.5(05)
May	129.0(08)	114.6(04)	259.2(17)	169.8(09)	11.2(02)	82.3(05)	275(17)	140.5(07)	210.3(13)	61.4(02)
June	45.0(01)	187(12)	193.2(09)	220.9(15)	5.9(03)	26.2(02)	216.2(08)	251(11)	-	252.4(07)
July	-	49.6(06)	8.5(04)	130(09)	-	64.0(04)	17.8(04)	251.2(11)	-	118.8(04)
August	-	48.6(06)	69.5(03)	64.5(06)	8.2(03)	27.1(02)	57.5(03)	142.8(13)	16.3(3)	4(01)
September	34(03)	10(03)	87.8(07)	97.5(08)	74.1(04)	-	84.5(08)	75(05)	42.6(04)	11.8(01)
October	291(14)	223.7(13)	574.3(17)	-	197.5(13)	114.7(08)	519.0(19)	382(15)	403.2(14)	255.8(13)
November	264(14)	206.3(10)	315.8(19)	-	279.0(15)	521.9(23)	276.3(16)	240(09)	235.1(09)	121.5(04)
December	141.3(11)	22.2(04)	85.9(07)	-	529.5(18)	156.9(11)	83.2(05)	-	147.0(05)	-
Total	1465.6(77)	1325.6(76)	2353.6(111)	1171.2(78)	1657.1(96)	1760(89)	2208.8	2217.4(99)	1559.9(69)	1145.5(45)

Table 3 : *Coconut extent and Census of Palms*

Estate	Bandirippuwa Main Research Centre	Rathmalagara Research Centre	Ambakelle Genetic Resource Centre	Maduruoya Genetic Resource Centre	Poththukulama Research Centre	Walpita Research Centre	Makandura Genetic Resource Centre	Pallama Seed Garden	Dunkannawa 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
Week 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 Gardens (Extent-ha)*

Extent	Bandirippuwa Main Research Centre	Rathmalagara Research Centre	Ambakelle Genetic Resource Centre	Maduruoya Genetic Resource Centre	Poththukulama Research Centre	Walpita Research Centre	Makandura Genetic Resource Centre	Pallama Seed Garden	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	990.48
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	2401.19

Table 5 : *Nut Production in Estates – 2003*

Pick	Bandirippuwa Main Research Centre	Rathmalagara Research Centre	Maduruoya Genetic Resource Centre	Poththukulama Research Centre	Walpita Research Centre	Makandura Genetic Resource Centre	Pallama Seed Garden	Ambakelle Genetic Resource Centre	Dunkannawa Research Centre	Total
Pick-1	49,715	60,899	74,263	48,957	13,731	57,979	54,769	160,031	2,090	543,516
Pick-2	82,002	80,536	34,244	81,977	24,502	87,918	114,889	156,635	2,782	628,915
Pick-3	98,292	105,984	39,852	124,595	32,230	90,083	86,974	343,926	4,338	861,110
Pick-4	95,931	98,912	60,044	162,998	23,331	78,779	85,548	294,964	2,779	876,047
Pick-5	104,828	81,131	39,276	148,142	22,458	66,779	80,297	376,056	3,031	696,763
Pick-6	109,828	105,611	61,427	121,094	10,675	66,159	87,457	217,339	2,654	717,641
Total	540,072	533,073	309,106	687,763	126,927	477,697	509,925	1,549,281	17,614	2,554,511

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 2003, is given in Table 1:

Table 1. *Staff position as at 31/12/2003*

Grade	Un-graded	Sp C1	C1 I	C1 II	C1 III	C1 IV	Total
Executive	01	-	08	11	20	15	55
Technical	-	36	12	17	-	-	65
Inter mediates	-	05	01	01	-	-	07
Clerical & Allied	-	24	05	07	-	-	36
Operative	-	21	11	15	-	-	47
Driver	-	18	05	07	-	-	30
Minor	-	48	15	19	-	-	82
Watcher	11	-	-	-	-	-	11
Grand Total	12	154	56	76	20	15	333

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 59 employees, amounting to Rs.15,067,600.00

Distress Loans : Granted for 46 employees amounting to Rs.3,150,881.00

Transport Loans : Granted for 27 employees amounting to Rs.1,299,350.00

Refrigerator Loans : Granted for 07 employees amounting to Rs.84,000.00

Loan Relief to Indebtedness

Loans : Granted for 09 employees amounting to Rs.67,500.00

Medical Aid: Rs.1,974,471.00 was reimbursed by the Medical Aid Scheme during the year 2003, and an amount of Rs.778,515.00 was distributed to 355 Members Savings Accounts.

The following medical clinics were conducted in the year

- Eye Clinic
- Blood Donation Programme
- Medical Check up for members and their family conducted by Asiri Hospitals (Pvt.) Ltd.

3.2 **Other facilities to employees**

(a) Financial assistance was also granted to the Multi-purpose Co-operative Society and the Recreation Club during the year 2003.

STAFF MATTERS

1. APPOINTMENTS

No appointments were given during the year 2003

2. RESIGNATIONS, RETIREMENTS, VACATION OF POSTS AND TERMINATIONS OF SERVICES AND DEATHS

The details are given in Table 1.

Table 1 :

Name	Designation	Division/Unit	Date
Resignations:			
Mr. G Gunarathbanda	Senior Lab/Field Attendant	Estate Management Division	31.01.03
Mrs. F F Faruk	Research Officer	Coconut Processing Research Division	28.02.03
Mr. F Jayasinghe	Manager (Estates)	Estates Management Division	17.05.03
Mr. P A C Chandrasekara	Watcher	Estates Management Division	22.05.03
Mt. N M S K Ranjith	Internal Auditor	Establishment Unit	30.09.03
Mr. U W B A Weragoda	Superintendent	Estates Management Division	25.11.03
Dr. L L W Somasiri	Acting Deputy Director(R)	Establishment Unit	31.12.03
Mrs. R D I Somasiri	Senior Audit Clerk	Establishment Unit	31.12.03
Retirements:			
Mr. T H I H Perera	Office Attendant	Establishment Unit	01.02.03
Mr. K D L Appuhamy	S. Electrician/Power House Operator/Plumber Fitter	Engineering Unit	28.06.03
Mr. H H J E Appuhamy	Senior Clerk	Estates Management Division	12.07.03
Mr. D E V R Vijetunga	L/F Assistant	Crop Protection Division	28.08.03
Mr. W M Ariyadasa	Vehicle Attendant	Establishment Unit	19.10.03
Mr. W P Periris	Senior Lab/Field Attendant	Agronomy Division	31.10.03
Mr. T M W Peiris	Senior Lab/Field Assistant	Genetics & Plant Breeding Division	07.12.03
Vacation of Posts:			
Mrs. A P Illangakoon	Library Assistant	Library	24.09.03

3. PROMOTIONS

3.1 PROMOTIONS IN NON-EXECUTIVE GRADES

Following Internal Promotions in Non-Executive Grades were implemented during the year 2003, as shown in Table 2. The effective date of these promotions was 01/01/2003.

Table 2: *Promotions in Non-Executive Grades during the year 2003*

Name	Designation	Division/Unit
CLASS 1 TO SPECIAL CLASS		
Technical Grade		
Mr. R D Sumasiri	Senior Book Keeper	Accounts Unit
Mr. N M R Sarathchandra	Senior Book Keeper	Accounts Unit
Mr. S M Sirisoma	Senior Book Keeper	Accounts Unit
Clerical and Allied Grade		
Mr. J A R Regimold	Senior Estates Clerk	Estates Management Division
Mrs. A S M S Abeywickrama	Senior Accounts Clerk	Accounts Unit
Operative Grade		
Mr. K L Ranasinghe	Senior Lab/Field Assistant	Soils & Plant Nutrition Division
Mr. W W F N Fernando	Senior Lab/Field Assistant	Crop Protection Division
Mr. M A Hemachandra	Senior Lab/Field Assistant	Genetics & Plant Breeding Division
Mr. A G B G Silva	Senior Supervisor	Estates Management Division
Mr. P A D M Appuhamy	Senior Lab/Field Assistant	Genetics & Plant Breeding Division
Mr. R M S G Ratnayaka	Senior Motor Mechanic	Engineering Unit
Drivers Grade		
Mr. M J A Mirando	Senior Tractor Driver	Estates Management Division
Minor Grade		
Mr. H A D Rexy	Senior Office Attendant	Establishment Unit
CLASS II TO CLASS I		
Technical Grade		
Mr. H M N Herath	Technical Officer	Genetics & Plant Breeding Division
Mrs. H L A Padmini	Technical Officer	Soils and Plant Nutrition Division

Intermediate Grade		
Name	**Designation**	**Division/Unit**
Mrs. M M S P Fernando	Stenographer (English)	Establishment Unit
Clerical Grade		
Mr. W A L Raj Fernando	Clerk/Typist	Estates Management Division
Mr. M A D M F Appuhamy	Clerk/Typist	Establishment Unit
Operative Grade		
Mr. M H Dhanasena	Lab & Field Assistant	Soils & Plant Nutrition Division
Mr. A A Sirinimal	Supervisor	Estates Management Division
Mr. A Sugathadasa	Supervisor	Estates Management Division
Driver Grade		
Mr K P S Dissanayake	Tractor Driver	Estates Management Division
Minor Grade		
Mr P David Perara	Electrician	Engineering Unit
Mr. R M N Sandasiri	Lab/Field Attendant	Tissue Culture Division

3.1 PROMOTIONS IN EXECUTIVE GRADES

Following Promotions in Executive Grades were granted during the year 2003, as shown in Table 3 and 4.

Table 3. *Promotions in Executive Grades during the year 2003*

Name	Designation	Division	Effective Date
Executive Grade Class II to Class I			
Dr. C S Ranasinghe	Head/Plant Physiology Division	Plant Physiology Division	13.09.2002
Dr. L K Weerakoon	Head/Tissue Culture Division	Tissue Culture Division	01.04.2003

Table 4.

Name	Designation	Division	Effective Date
Executive Grade Class III to Class II			
Mrs. S R Samarajeewa	Senior Research Officer	Agronomy Division	13.09.2002
Dr. C K Bandaranayake	Senior Research Officer	Genetics & Plant Breeding Division	01.04.2003

4. TRANSFERS

Mr. B M Jayathilaka, Senior Book keeper, from Estates Management Division to Internal Audit Unit on 06 January

Mr. D M Sarathchandra, Lab and Field Assistant, from Genetics & Plant Breeding Division to Rathmalagara Research Sub Station on 01 January

Mr. G R A Dharmasena , Technical Officer, from Extension Services Division to processing Research Division on 01 January

Mr. W S Fernando, Watcher, from Pallama Seed Garden to Poththukuulama Research Sub Station 15 January

Mr. Upali Abeyrathne, Watcher, from Maduruoya Seed Garden to Pallama Seed Garden on 18 January

Mr. W A Haral Upali, Field Officer, from Walpita Estate to Maduruoya Seed Garden 14 January

Mr. W M Upali Rathnayaka, Superintendent, from Maduruoya Seed Garden to Pallama Seed Garden 15 January

Mr. A N Ekneligoda, Superintendent, Rathmalagara Research Sub Station to Makandura Seed Garden 05 February

Mr. Nimal Hemasiri, Superintendent, from Makandura Seed Garden to Walpita Estate 15 January

Mr. W S M A Fernando, Superintendent, from Pallama Seed Garden to Rathmalagara Research Sub Station 15 January

Mr. Nimal Chandrasiri, Field officer, from Bandirippuwa Estate to Maduruoya Seed Garden 13 January

Mr. M A Sunil Fernando, Supervisor, from Maduruoya Seed Garden to Isolated Seed Garden 15 January

Mr. D M Jayawardana, Clerk Typist, Poththukulama Research Sub Station to Rathmalagara Research Sub Station 15 January

Mr. S A Sumanawathi, Field Attendant, from Pallama Seed Garden to Poththukulama Research Sub Station 15 January

Mr. S Marasinghe, Field Attendant, from Poththukulama Research Sub Station to Pallama Seed Garden 15 January

Mr. A Sugathadasa, Supervisor from Isolated Seed Garden to Bandirippuwa Estate15 January

5. OVERSEAS STUDY LEAVE

Table 5. *Full pay overseas leave*

Name	Designation	Period	Purpose	Institute
Mr. A M A P G Gunawardena	Extension Officer	29/10/2003 - 28/12/2005	Postgraduate Training to M.Sc.	University of Agriculture and Technology, India
Mrs L L W C Yalegama	Research Officer	16/11/2003 - 15/11/2005	Postgraduate Training to M.Sc.	University of Maharashtra, India

6. LOCAL TRAININGS (More than 5 days)

Mr. E P Gunapala/Deputy Director(Adm. & Fin.) followed a Diploma in Human Rights Course at the Institute of Human Rights, 03 months from 22 February 2003 (on Saturday s).

Mr. N M S K Ranjith/Internal Auditor followed a Certificate course in Internal Auditing, at the Institute of Government Accounts and Finance, 60 hours from March 2003.

Mr. S S Rajapaksa/Technical Officer followed a training course on Net Working with Windows 2000 Server at the Computing Service Center 3 weeks from 9 June 2003

7. OVERSEAS VISITS

Mr. A D Samarajeewa/Research Officer participated visiting of the sites of the ADB funded project on "Developing Sustainable coconut –based Income Generating Technologies in poor Rural Communities in India from 09 to 12 March.

Dr. M T N Fernando/Senior Research Officer participated at the Regional Workshop on Assessment of Impacts & Adaptation to climate change in Bangkok, Thailand from 23 to 28 March

Dr. (Mrs.) L C P Fernando/Head, Crop Protection Division participated at the international workshop on Eriophid Mite on Coconut in Bangalore, India from 03 to 08 April

Mr. I R Wickramananda/Senior Research Officer participated the international conference on coconut mite in India from 03 to 08 April

Dr. (Mrs) C Jayasekara/Director, Coconut Research Institute participated the International conference on coconut mite in India from 03 to 08 April

Dr. U P de S Waidyanatha/Chairman Coconut Research Board participated in World Bank Sponsored Regional workshop on Agriculture Extension Reforms and in the International Coconut Summit Kochi, India from 07 to 11 May

Mr. P A H N Appuhamy, Head/Extension Services Division participated in ISNARS final workshop on "performance based management systems" (PBMS) in Hanoi, Vietnam from 16 to 20 June.

Dr. L L W Somasiri/Acting Deputy Director (Research) participated in ISNARS final workshop on "performance based management system" (PBMS) in Hanoi, Vietnam form 16 to 20 June.

Dr.(Mrs.) C Jayasekara/ Director, Coconut Research Institute participated in ISNARS final workshop on "performance based management systems" (PBMS) workshop in Hanoi, Vietnam form 16 to 20 June.

Mr. I M S K Idirisinghe/Extension Officer participated in ISNARS final workshop on "performance based management systems" (PBMS) in Hanoi, Vietnam from 16 to 20 June.

Mr. J M D T Everard, Head/Genetics & Plant Breeding Division participated in ISNAR final workshop on "performance based management systems" (PBMS) in Hanoi, Vietnam form 16 to 20 June.

Mr. E S Santha/ Senior Technical Officer to bring coconut germplasm from Papua New Guinea from 18 June to 18 July

Dr. A A F L K Perara/Senior Research Officer to bring coconut germplasm from Papua New Guinea from 18 June to 18 July

Mr. K D P P Gunathilaka/Research Officer participated the coconut candy coconut sugar & bukayo making course, to attend the annual meeting of ADB funded project on Poverty reduction in coconut communities and visiting project sites in Davavo City and to attend Philippines coconut exhibition in Philippines from 16 to 27 August.

Mr. A D Samarajeewa/Research Officer, participated at the Annual Progress Review meeting of the ADB funded Project titled Developing sustainable coconut based income generating technologies in poor rural communities in Philippines from 16 to 26 August.

Mr. K V N N Jayalath /Technical Officer, to present a paper titled "Shifting from furname oil to dendrothermal in desiccated coconut in Sri Lanka in Philippines from 20 to 23 October

Dr. T S G Peiris/Principal Biometrician to study novel-methods in seasonal climate predication at the International Research Institute – USA from 01 to 22 November

Dr.(Mrs.) C Jayasekara/ Director, Coconut Research Institute participated at the coconut Genetic Resources Network (COGENT) steering committee meeting in Merida, Mexico from 06 to 17 November

8. OVERSEAS TRAININGS

Mrs P I P Perera/Research Officer followed a short –term training in Biotechnology at IRD (Institute de Recherdhe pur le Development), France from 01 July to 01 November.

Mr. R P B S H Senaratne/Research Officer participated a training programme in Malaysian Palm Oil Board, Malaysia from 05 to 18 October.

Mrs. H D D Bandupriya/Research Officer participated in a short – term training in biotechnology at a foreign University Institution, USA from 01 November 2003 to 28 February 2004.

Dr.(Mrs.) L K Weerakoon/Senior Research Officer followed a short – term training on Plant Tissue Culture and Genetics transformation, USA from 03 November to 01 December .

Dr. M T N Fernanado/Senior Research Officer followed training on developing econometric models to assess the socioeconomic effects of climate change on Coconut Sector in USA from 11 October to 05 November.

Mr. J M D T Everard/ Head, Genetics & Plant Breeding participated in a training programme on Agricultural Research Management in Hyderabad, India from 11 to 30 November.

9. 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 2002.

Buses	-	03
Lorries	-	02
Vans	-	08
Cars	-	01
Cabs	-	13
Jeeps	-	06
Motor bicycles	-	45
Land Vehicles	-	23
Three Wheelers	-	01

10. FINANCE UNIT

Total budgetary allocation for this year is 128 million and out of which 101 million under recurrent and 27 million under capital expenditure. Income forecast for this year was 47 million. Therefore the government grant was 74 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.

11. 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 2003.

- Construction of 06 Nos toilets at Pallama Seed Garden
- Renovation to staff quarters BE/GRIII/04 at Bandirippuwa Estate
- Improvements to the Dairy Shed at Bandirippuwa Estate
- Construction of an Agro Well at Bandirippuwa Estate
- Construction of a Tractor Garage at Bandirippuwa Estate
- Construction of a Labour Rest Room at Maduru Oya Seed Garden
- Construction of a Tractor Garage at Maduru Oya Seed Garden
- Repairs to pavements of the Superintendent's Bungalow at Pallama Seed Garden
- Supply, Installation and Commissioning of a Submersible Water Pump at Bandirippuwa Estate
- Repairs to the OIC Bungalow at Dunkannawa Estate
- Construction of a Goat Shed at Poththukulama Estate
- Construction of Water Distribution System at Bandirippuwa Estate
- Supply, Installation and Commissioning of 300 KVA Generator at Bandirippuwa Estate
- Irrigation Development Works at Maduru Oya Seed Garden
- Supply of Furniture to the New Laboratary at Bandirippuwa Estate.
- Repair works to the Men's Hostel at Bandirippuwa Estate.

STAFF PUBLICATIONS AND COMMUNICATIONS AT SCIENTIFIC MEETINGS

JOURNALS, PRESENTATIONS AT SEMINAR/WORKSHOPS AND SCIENTIFIC SESSIONS

Bandaranayake, C.K. (2003). Investigation of the feasibility of constructing a map for coconut with several F2 families using computer simulated data (CORD XIX (1) : 59-68.

Dasanayake, P.N, J.M.D.T. Everard, E.H. Karunanayake, and H.G Nandadasa,. (2003) Characterization of coconut germplasm by micro-satellite markers. Tropical Agricultural Research 15:51-61.

Fernando, S.C, J.L. Verdeil, V Hocher, L.K. Weerakoon and K Hirimburegama (2003) Histological analysis of plant regeneration from plumule explants of Cocos nucifera. Plant Cell, Tissue and Organ Culture 72: 281-284.

Fernando, L.C.P. (2003) Experiences on the role of pheromones in pest management in palms. Journal of Plantation Crops 31(2).

Fernando, L.C.P, N.S. Arachchige, T.S.G. Peiris (2003) Distribution pattern of coconut mite and its prediction in coconut palm. Experimental and Applied Acaralogy, Vol. 31, 71-78.

Madurapperuma, W.S.M, C.S. Ranasinghe (2003). Evaluation of a suitable method to apply zinc on the Leaf Scorch Decline (LSD) affected coconut (Cocos nucifera L.) palms. Proc. Sri Lanka Assoc. Advmt. Sci. 59, (in press).

P N Dasanayake, J.M.D. T Everard, E.H. Karunanayake and H.G. Nandadasa (2003) Genetic relatedness of coconut (Cocos nucifera L.) germplasm in Sri Lanka as revealed by Simple Sequence Repeat Markers : Proc. Sri Lanka Assoc. Advmt. Sci. 59(1):59.

Peiris, T.S.G. and Jenet Riley (2002). Aggregation of multidisciplinary indicators in space. Proceeding of the International Biometrics Conference held in Freiburg, Germany from 21-26 July.

Peiris, T.S.G. W. Pramuditha, and R. Abeynayake, (2002) reduction of experimental error in coconut trials. Proceeding of the International Biometrics Conference held in Freiburg, Germany from 21-26 July.

Perera, L, J.R. Russel, Proven, J. and W. Powell (2003). Studying genetic relationships among coconut varieties/populations using micro-satellite markers. Euphytica 132: 121-128.

Perris, T.S.G. (2002) "Effect of temporal scale aggregation on climate change studies" Proceeding of the International workshop on regional Integrated Assessment of Climate Impacts held at the IL CIOCCO Hotel in Castelvevvhiro, Pascoli, Italy from 16-20 September.

Ranasinghe, S. U.P.de.S Waidyanatha (2003) Ethrel stimulation of inflorescence sap flow in tapped coconut (*Cocos nucifera L.*) palms. *Experimental Agriculture* 39, 1-6.

Ranasinghe, S. R. Wimalasekara, P.S.A. de Saram, W.P.K.F. Fernando, (2003). Preservation of young king coconuts (*Cocos nucifera var.* aurantiaca) during simulated sea shipment. *Asean Food Journal* 12(3), 175-181.

Ransinghe, C.S. (2003). The water requirement of the coconut palm and its response to irrigation. Public seminar on 'Coconut Irrigation - Technology and policy' Savsiripaya, Wijerama Mawatha, Colombo 07. 07 November 2003.

Tennakoon, N.A. 2003. Organic manure as a low cost coconut fertilizer for small holders. A News Article, "Daily News", 18th October, 2003 p.20.

Tennakoon, U.G.M.B.K. and L.L.W. Somasiri, 2003. Efficiency of dolomite and kiescrite as magnesium fertilizers on two coconut growing soils. Proceedings of the Sri Lanka Association for the Advancement of Science 59(1).

Tennakoon, N.A. 2003. Potassium status of coconut plantation soils in Sri Lanka. A paper presented at the workshop on IPI-NFS. International workshop on Importance Potash fertilizer for sustainable production of plantations and food crops in Sri Lanka, held at Hotel Galadari, Colombo, from 1st - 2nd December 2003.

Wickramananda, I.R. and L.C.P. Fernando, (2002) Efficacy of four botanical pesticides on three major pests of coconut (Cocos nucifera L.). In Plantation Crops Research and Development in the new millennium. Eds; P Rethinam, H H Khan, V. M. Reddy, P. K. Mandal & K. Suresh. Proceedings of PLACROSYM XIV 12-15 Dec. 2000, Coconut Development Board, Kochi, India pp. 214-217.

Wijebandara, I. C.S. Ranasinghe (2003). Effect of micronutrients and common salt on the performance of rapid decline affected coconut (Cocos nucifera L.) palms. Proc. Sri Lanka Assoc. Advmt. Sci. 59, (in press).

Wijebandara, D.M.D.I. (2003). Nutritional aspects of leaf scorch decline of coconut; contributions from Soils and Plant Nutrition Division. Paper presented at in-house seminar, held in Coconut Research Institute on 2nd April.

Wijebandara, D.M.D.I. and L.L.W. Somasiri, (2003). Evaluation of nitrogen, phosphorus, potassium and magnesium availability in three soils by bioassay. Proceedings of the Sri Lanka Association for the Advancement of Science.

Wijebandara, D.M.D.I. L.L.W. Somasiri, and C.P.A. Kurundukumbura, 2003. Evaluation of residual P effect of Andigama series soil after long term rock phosphate application. Paper presented at Young Scientist Forum organized by the Soil Science Society of Sri Lanka on 29th August.

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 Centers, five Research Centers, 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**			
	2000	**2001**	**2002**	**2003**
Treasury Grant – Recurrent	63.89	63.50	57.00	52.77
Treasury Grant – Capital	27.72	12.70	7.25	27.50
Income Self-finance Units	27.77	41.95	35.18	46.98
CRI Own Income	3.15	2.40	3.43	5.75
CESS Grant	45.17	14.12	14.88	12.50
Donor Funded Projects	2.15	3.63	7.15	7.72
Total	169.85	138.30	124.89	153.22

As shown in Table 1, the consolidated funds have increased by 25% in the year 2003 compared to year 2002. The income generation of self-financing units had increased by 33% when compared to previous year.

Table 2 : *Financial progress of recurrent and capital expenditure*

Description	**Rs. Million**		**(Decrease) % Increase**
	2002	**2003**	
Personnel Emoluments	51.63	55.59	7.5%
Travelling Expenses	1.61	0.93	(73%)
Supplies and Requisites	6.87	6.32	(9%)
Maintenance Expenses	10.02	10.18	2%
Contractual Expenses	4.71	4.14	(14%)
Other Recurrent Expenses	0.87	0.92	5%
Total Recurrent Expenses	**75.71**	**78.08**	**3%**
Total Capital Expenses	**7.44**	**21.78**	

The staff position of the CRI was 748 employees during the year 2003. Out of them 334 were permanent employees, five were on contract basis and 409 were daily paid workers. As

indicated in Table 2, 71% 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.

Following factors were negatively influenced the recurrent budget.

- The Department of National Budget had instructed to curtail the recurrent expenditure by 2% except salaries and wages
- Had to pay increments to offices who have reached the maximum of their salary scales.
- Increase of Statutory Board Chairman allowance

Table 3 : *Financial Progress of Self-financing Units*

Seed Gardens/ Research Centers	Year 2003		Surplus/ (Deficit)
	Income Rs. Million	Expenditure Rs. Million	
Ambekela Genetic Resources Center	17.57	6.99	10.58
Pallama Genetic Resources Center	4.50	4.46	0.04
Makandura Genetic Resources Center	4.23	2.38	1.86
Maduruoya Genetic Resources Center	2.94	2.30	0.64
Bandirippwa Research Staton	4.72	4.93	-0.20
Rathmalagara Research Center	5.63	5.25	0.38
Walpita Research Center	1.50	1.19	0.31
Pottukulama Research Center	5.71	3.54	2.17
Dunkannawa Research Center	0.18	0.89	-0.70
Total	**46.98**	**31.93**	**15.07**

Pallama Genetic Resource Center and Dunkannawa Research Center had been vested recently and therefore these two estates are in an improvement stage.

Estimated and achieved coconut production was 5,016,000 and 4,721,459 respectively. The main reason for this yield reduction was due to poor distribution of rainfall.

COCONUT RESEARCH INSTITUTE

ESTABLISED UNDER COCONUT DEVELOPMENT ACT NO 46 OF 1971

STATEMENT OF FINANACIAL POSITION AS AT 31 st DECEMBER 2003

ASSETS		**YEAR 2003**	**YEAR 2003**	**YEAR 2002**
Non - Current Assets				
Property,Plant & Equipment	**Note 01**	140,210,136.63		135,172,632.53
Research & Development	**Note 1.1**	6,253,336.23		2,254,292.84
			146,463,472.86	137,426,925.37
Current Assets				
Stocks	**Note 02**	20,772,635.36		12,689,897.71
Debtors less Provision	**Note 03**	1,893,122.33		2,288,037.40
Purchases Advance	**Note 04**	537,958.32		1,850,659.77
Loan & Advances to Employee	**Note 05**	16,660,502.63		16,289,177.58
Deposits Receivable		134,400.00		134,400.00
Saving Diposits	**Note 06**	119,844.11		576,308.13
Prepayments		892,890.95		1,095,808.58
I.A.E.A.Projects		5,513.29		5,513.29
Cash-in-Transit		6,519,855.24		-
Cash & Cash equivalents	**Note 07**	11,197,374.16		14,391,227.49
			58,734,096.39	49,321,029.95
Total Assets			**205,197,569.25**	**186,747,955.32**
LIABILITIES				
Current Liabilities				
Sundry Creditors	**Note 08**	237,063.60		138,067.85
Accrued Expences		8,840,985.41		4,220,385.44
Expences Creditors		1,124,613.20		1,294,584.75
Diposit Payable	**Note 09**	257,398.34		346,228.85
On Going Projects	**Note 10**	3,051,108.03		8,149,849.44
			13,511,168.58	14,149,116.33
Non - Current Liabilities				
Provision for Gratuity			30,353,223.91	28,415,013.01
Total Liabilities			**43,864,392.49**	**42,564,129.34**
Total Net Assets			**161,333,176.76**	**144,183,825.98**
NET ASSETS / EQUITY				
Contributed Capital	**Note 11**	249,981,959.10		223,402,973.86
Foreign Aid		634,078.78		634,078.78
Local Aid		4,819,171.82		4,819,171.82
Capital Reserves	**Note 12**	11,218,173.46		20,025,001.95
Revenue Reserve	**Note 13**	(105,320,206.40)		(104,697,400.43)
			161,333,176.76	**144,183,825.98**
Total Net Assets / Equity			**161,333,176.76**	**144,183,825.98**

.....	.....	.....
Deputy Director (A & F)	**Director**	**Chairman**
Coconut Research Board	**Coconut Research Board**	**Coconut Research Board**

COCONUT RESEARCH INSTITUTE
STATEMENT OF FINANCIAL PERFORMANCE FOR THE YEAR ENDED 31 st DECEMBER 2003
ILLUSTRATION THE CLASSIFICATION OF EXPENSES BY NATURE

	Year 2003 Rs.	Year 2002 Rs.
Operating Revenue		
Recurrent Grant	52,770,000.00	57,000,000.00
Estate Income	40,549,946.66	43,153,889.23
Interest on loan & Invesment	657,953.59	683,863.67
Income from Motor Vehicles	873,649.54	408,132.18
Sundry Income	3,837,287.56	2,262,279.85
Sales of Pheromone	121,350.00	77,653.80
Sales of Monocrotophose	260,720.00	-
	99,070,907.35	**103,585,818.73**
Operating Expenses		
Personal Emoluments		
Salaries Allowances & Over Time	46,120,553.71	48,089,679.32
Boards Contribution to EPF/ETF	6,517,765.96	6,528,894.46
Boards Contribution to Medical Aid	2,642,800.35	2,638,795.85
Coconut Allowances	303,996.48	489,029.62
Estate General Charges/Upkeep/Cultivation& Harvesting	17,708,382.71	30,869,610.78
Travelling	932,325.24	1,606,050.39
Supplies & Consumable used	6,321,110.98	6,870,069.43
Maintainance	10,150,298.40	10,024,891.47
Contractual Services	4,136,872.22	4,709,276.93
Depreciation & Amortisation Expenses	11,029,654.00	10,520,727.15
Other Operating Expenses	916,953.48	873,050.87
Total Operating Expenses	**106,780,713.53**	**123,220,076.27**
Surplus / (Deficit) from Operating Activities	**- 7,709,806.18**	**- 19,634,257.54**
Finance Cost	-	-
Gain on Sales of Property Plant & Equipments	2,036,057.00	-
Total Non Operating Revenue (Expenses)	**- 5,673,749.18**	**- 19,634,257.54**
Net Surplus / (Deficit) Before Extra Ordinary Items	-	-
Extra Ordinary Items	-	-
Net Surplus / (Deficit) for the period	**- 5,673,749.18**	**- 19,634,257.54**

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Coconut Research Institute
Lunuwila