COCONUT RESEARCH INSTITUTE - REPORT FOR 2001

COCONUT RESEARCH BOARD

COCONUT RESEARCH INSTITUTE OF SRI LANKA

REPORT FOR 2001

COCONUT RESEARCH BOARD

REPORT OF THE

COCONUT RESEARCH INSTITUTE

FOR 2001

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THE COCONUT RESEARCH INSTITUTE OF SRI LANKA

INTRODUCTION

The Coconut Research Institute was established in 1929, as Coconut Research Scheme under the Council Research Ordinance No 29 of 1928. The team established it's head quarters at Bandirrippuwa Estate, Lunuwila (NWP). With the enactment of Coconut research Act No.37 in 1950, the Coconut Research Scheme was renamed 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.

VISION OF THE CRI

To be the Centre of Excellence in Coconut Research,
Technology Development and Technology Transfer.

MISSION OF THE CRI

Our Mission is to Generate Knowledge and Technology Through Excellence in Research Towards increasing Productivity and Profitability of Coconut. In the Pursuit of this Mission we Endeavour to Nurture Motivate our Staff to Excel.

OBJECTIVES, GOALS AND SERVICES OF THE INSTITUTE

As stated in the mission to achieve its specific objectives of increasing productivity, profitability, and competitiveness of the coconut industry, CRI is expected to engage in research and service functions efficiently and effectively in the next five years as given below.

1. To undertake research on:

    * Genetics of the coconut palm, coconut breeding and crop improvement
    * Cultivation and management of the crop
    * Physiology of the coconut palm in relation to growth, yield and other functions
    * Development of coconut based farming systems
    * Pest and disease control
    * Quality control, value addition, and product diversification of coconut

    For generating technology and knowledge for the benefit of the coconut industry.

2. To disseminate technologies and information on coconut and associated production systems and coconut processing to end-users through services of the Institute, Coconut cultivation Board, and the Coconut Development Authority to achieve national yield of over 3000 million coconuts in three years.

3. To supply improved Seed nuts for the national replanting programme to meet 20000 acres replanting/under planting target with improved seed nuts.
   Key Result areas - Technology adoption.

4. To provide specialized analytical services and certification for the exports and pest control services in outbreak situations.

5. To ensure committed and competent research staff and effective administration, technical and support staff by motivation developing their capacity.

6. To recommend and advocate the formulation of policy.

7. To achieve excellence as a centre for coconut research within five years.

REPORT OF THT ACTING DIRECTOR AND DEPUTY DIRECTOR RESEARCH
C Jayasekara, Ph D (Qld)

1. GENERAL

The national coconut production this year estimated at 2796 million nuts, was 9.7 per cent less compared to the peak output recorded in the previous-year. A severe drought that prevailed in the coconut triangle and many other parts of the island contributed to this drop in production. However, estates that implemented good management practices maintained relatively higher yields. A reduction in the application of fertilizer during 2000 and 2001 due to low nut prices also possibly negatively affected on the nut yield.

The export volume of kernel and other coconut products also declined due to low production and high nut prices that prevailed during the latter part of the year. The export earnings from coconut products was Rs 7,348 million. Total house hold nut consumption during the year was estimated to be 1,892 million nuts. During the fourth quarter of the year, fresh nut prices as well as the price of coconut oil increased sharply owing to the short supply of nuts. The average fresh nut price during the year was recorded as Rs 10.00, and hence the total contribution from fresh nuts and the value added exports to the national economy was approximately Rs 16,068 million. Furthermore, when local usage of coconut as a source of fat, protein, fuel (shell and fronds), alcohol, construction material, and timber are taken into account, contribution of the crop to the national economy should have been much higher.

The allocation for the CRI from the consolidated fund and the coconut cess, was Rs 145,285,000 and Rs 14,033,000 respectively for its research and maintenance. This amount was mere 0.9% of the value coconut contributed to the national economy.

The five-year research programme implemented in 1996 consisted of 128 applied and basic "thrust areas" covering more than 200 experiments. The Research Committee comprehensively reviewed this research programme in the first quarter of 2001. It was decided to terminate experiments that had provided adequate data. Several new recommendations arising out of the experiments were made available to growers. Application of 2-5% ethrel to the axil of the infloresence to increase toddy production Other long-term experiments will be continued for few more years. Several new research areas were identified and new research proposals were formulated after several sessions of discussions among research staff. However, except for a few experiments, the implementation of the new research programme was not possible due to shortage of funds. The progress of the rest of the research programme was satisfactory. Most of the field experiments were conducted on estates belonging to Plantation Companies, Coconut Cultivation Board, and on substations of the Institute.

A significant achievement during the year was the establishment of a hundred and twelve coconut-based crop models in coconut smallholdings distributed among all coconut growing districts, excluding the North and East. The Second phase of

the Perennial Crop Development Project provided the financial assistance for this programme.

A multidisciplinary research project was launched to study the 'Rapid Decline Syndrome' (RDS) of coconut palms. The Institute successfully obtained technical assistance for a period of one year from the Food and Agriculture Organization (FAO) of the United Nations to work on the RDS. Regular mapping of the affected palms, at tri-monthly intervals, for a period of two years indicated that the RDS symptoms are gradually spreading to adjoining palms, an observation which requires further confirmation.

Another noteworthy achievement was the successful regeneration of fifty-seven clonal coconut plants by plumule, immature embryo, leaf, and meristem culture. Some of these cultured plants were planted in Bandirippuwa, Daisy Valley, and Lenawa estates.

The two Seed Gardens at Ambakelle and Maduru-Oya maintained by the Institute recorded a total production of 1,366,165 seed nuts during the year, representing a 13 % increase compared to the previous year. CRI supplied 1,315,640 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. The total extent planted under this seed garden development programme is 50 hectares.

Exchange of germplasm with Fiji was postponed due to political instability and the consequent risk of germplasm exploration in these countries. Under the germplasm exchange programme with India, four Sri Lankan cultivars of coconut were given to India, but the acquisition of germplasm from India was postponed with a view to obtaining germplasm from Ivory Coast as the first consignment.

The Coconut Processing Research Division and Molecular Biology research group shifted to the new two-storied laboratory complex. Equipping the new laboratory was continued with the procurement of equipments through the Consolidated Fund, as well as from the Science and Technology Personnel Development Project. Furnishing of the laboratory is being continued.

The Institute continued to provide assistance to the coconut estate sector, through the 'Persuasive Extension Programme' and organized several field days on selected topics at the request of the Coconut Growers Association. This gave an opportunity for the research scientists to establish a closer interaction with the planting community and to get a feedback towards their research programmes. Several 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.

The Institute conducted three workshops inviting DC millers, Oil millers, Staff of Agriculture Engineering Division, University of Peradeniya, and National Services Bureau, Kurunegala with a view to identifying problems encountered by the processing sector and to initiate collaborative research with the University to solve

the problems. Similarly, another meeting was held inviting small scale manufactures of coconut oil with a view to improving the quality and marketability of coconut oil and to promote the use of coconut oil for culinary purposes. A third meeting was held with the managers of Distillery Companies and staff of the Excise Department to identify problems faced by the arrack industry and in order to strengthen the toddy tapping industry and to make recommendations to the government for improving the arrack industry.

Training of the first batch of selected youth on coconut farm management was successfully completed, giving them three months attachment training within CRI estates on coconut cultivation and farm management. Arrangements were made to place these trained Farm Managers on private estates.

The Council for Agricultural Research Policy (CARP) continued to provide assistance to the Institute by funding research projects and facilitating electronic library facilities. Under the vermiculture project funded by CARP the institute received Rs. 4,61000.00.

The Coconut Cess fund provided assistance for strengthening of infrastructural facilities for research and Seed Gardens, to provide postgraduate training for research staff, and for the funding of special research projects to meet current needs of the industry. The total allocation from the CESS fund for special projects was Rs. 19,339,130.00. Out of the this amount CRI received Rs. 3,471,100.00 for 2001.

Development of a performance based management system for the CRI was continued with the assistance of the Asian Development Bank (ADB) and International Service for National Agriculture Research (ISNAR). As a part of this exercise, a series of workshops was conducted with the participation of the Institute staff and representatives from all categories of stakeholders of the coconut industry. This was to formulate strategic plans with a view to repositioning the CRI to meet new challenges of the coconut industry and for priority setting of research activities.

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

The Institute was financed by the government and from the revenue of its estates. Budget restrictions imposed by the government, affected the effective implementation of the action plan of the Institute and compelled curtailment of some facilities provided to the staff.

2. RESEARCH AND DEVELOPMENT

A brief account of the research and development activities of the Coconut Research Institute is given below.

2.1 Agronomy Division

Research projects on soil water conservation in coconut lands, productivity improvement through intercropping and animal husbandry, rehabilitation of low yielding plantations, weed control, and socio-economic studies continued with satisfactory progress.

A severe drought prevailed in the coconut triangle, resulting in a decline of the coconut yield by almost one third. Nevertheless, estates that implemented appropriate soil water conservation practices such as husk burial and mulching were not badly affected by drought and recorded relatively high yield. Husk mulching reduced the soil temperature by about 10^0C within the manure circle of the husk-mulched palms compared to control palms.

Coconut seedlings planted in degraded coconut soils (Andigama series) showed better growth with early flowering, when planted in 1.3m x 1.3m x 1.3m large planting holes in 1.3m x 1.0m trenches compared to normal planting in 1.0m x1.0m x 1.0m holes.

The cultivation of short-term forest species was tested, as another method of rehabilitation of degraded shallow lateritic soils. Compared to other forest species, *Macaranga roxburghii* (Kenda) improved soil organic matter content.

The on-farm adaptive research programme funded by the Asian Development Bank (ADB) under the Second Perennial Crop Development Project progressed satisfactorily. A hundred and twelve demonstration sites were established in 16 administrative districts which proved to be an effective extension tool in transferring technologies on coconut based farming systems due to its multiplication effect.

Under the integrated animal husbandry programme in coconut lands, research on low-cost poultry production systems received high priority. Three chicken crosses/strains namely- indigenous, CPRS x indigenous, and CPRS (Karandagolla) were evaluated for production and adaptability, in a restricted scavenging system in coconut lands with the supplementation of a formulated ration. Preliminary results showed that CPRS was superior to the other two strains.

The impact of three price policy instruments namely: (i) coconut cultivation subsidy, (ii) import tariff on edible oils, and (iii) export tax/Cess on desiccated coconut was analysed. The coconut cultivation subsidy has had a significant positive impact on total national coconut production, with a 13 year lag period on the initial investment. The protection of the edible oil market with a high tariff rate resulted in only a 12 percent increase in the domestic coconut oil supply, while creating an unfavourable impact on coconut oil consumers.

Another socio-economic study examined the potential of the expansion of toddy tapping through the promotion of coconut-based arrack industry. The study revealed that the arrack and beer price and consumer income were the significant variables, which determined arrack consumption in the country. Arrack consumption would alter in consequence of manipulation of the tax rate, which is 70% at present.

2.2 Genetics and Plant Breeding Division

The evaluation of improved coconut cultivars in different agro-ecological environments continuously demonstrated the superiority in yield of inter-varietal hybrids, *dwarf green x tall and dwarf yellow x tall* (CRIC 65) over pure tall cultivars, *tall x tall* (CRIC 60), *Moorock* and *plus palm tall* selections at two comparable sites at Bandirippuwa (Lunuwila), Thammenna (Puttalam) in two consecutive years. The trial is now in the 8th year of its production and showed signs of yield stability. In terms of nut yield, *dwarf green x tall with 89 nuts/palm/year* (app. 16900 nuts/ha) and *dwarf yellow x tall with 76 nuts/palm/year* (14600nuts/ha) significantly out performed *tall x tall with 64 nuts/palm/year* (app. 12500 nuts/ha), *plus palm tall with 59 nuts/palm/year* (11000 nuts/h) and *Moorock tall with 52 nuts/palm/year* (10000 nuts/ha) during the past two years.

The copra yield per nut was less in both inter-varietal hybrids, *dwarf green x tall* (208 g/nut at Bandirippuwa and 179 g/nut at Thammenna) and *dwarf yellow x tall* (225 g/ nut at Bandirippuwa and 200g/nut at Thammenna) compared to tall cultivars, *tall x tall* (250 g/nut at Bandirippuwa and 227 g/nut at Thammenna, *Moorock tall* (279 g/nut at Bandirippuwa and 210 g/nut at Thammenna) and plus palms (250 g/nut at Bandirippuwa and 221 g/nut at Thammenna). However, copra yield per unit land was higher for inter-varietal hybrids, *dwarf green x tall* and *dwarf yellow x tall* than *tall, tall x tall, plus palm*, and *Moorock tall.*

The production and distribution of CRISL 98, for adaptive trials were continued, as there was a substantial demand from farmers. The seeds were produced by hand pollination of 51 tall palms at ISG using pollen collected from *San Ramon* palms at Bandirippuwa. In the year 2001, a total of 3797 seedlings were distributed predominantly among growers in Kurunegala (1228), Puttalam (1435), Gampaha (402), Galle (310), Kegalle (151), Pollonnaruwa (62), and Matale (60) districts. A programme was formulated to distribute Ambakelle Special along with CRISL 98 for comparative evaluation of the CRISL 98, under farmer conditions.

Establishment of Pallama Seed Garden for mass production of CRISL 98 continued with a rapid progress. During the year, 1038 *San Ramon* (salfed) and 607 selected tall from Isolated Seed Garden (ISG) were planted in field numbers 1,2,and 3. The final stand at the end of 2001 was, 3004 tall seedlings (710,1058 and 1236 seedlings, respectively in Field numbers 1,2 and 3) and 2605 *San Ramon* seedlings (333,529 and 598 seedlings, respectively in Field numbers 1,2,3 and 1145 seedlings in guard rows). The limited availability of pure *San Ramon* mother palms restricted the production rate of *San Ramon seedlings.*

Collection and conservation of coconut germplasm continued. Three more accessions from Aparakka, Digdenipotha, and Bathigama in the Matara district were added to the collection. The field gene banks at Bandirippuwa, Poththukulama, Lenawa, and Raddegoda were maintained satisfactorily. Kohombana Gene Bank located at the Coconut Cultivation Board (CCB) premises, Gonagolla, Amparai also made good progress with the ecotypes collected from the neighbourhood, despite extremely harsh weather conditions that prevailed in the area. The Coconut Genetic Resource Database (CGRD) of the COGENT was up-dated with the progress of rejuvenated accessions in the field gene banks. Nine more accessions, *Ran*

thembili, Mirishena dwarf, Mirishena semi dwarf, Wellawa, Horakelle, Rathran thembili, Brazilian green dwarf, King coconut, and *Kamandala* at Poththukulama Research Station were characterized for early growth and reproductive descriptors.

DNA assay studies consistently revealed that coconut in Sri Lanka basically falls into two groups, one representing the genome of African tall coconuts and the other of Pacific coconuts. All tall coconuts, except the Philippine type, *San Ramon* and its derivatives fell into the former group, while dwarf coconuts fell into the group constituting the Philippine types. Dwarf coconuts probably retained the original coconut genome due to their predominantly inbreeding behaviour. Three germplasm accessions collected from ancient villages in Amparai, shared a somewhat unique genome, probably indicating a common source of origin, different from domesticated coconuts in other parts of the country. The need for germplasm enrichment by exotic introductions for further genetic improvement has been identified as high priority research and negotiations are being continued with Ivory Coast, India, and Fiji.

Construction of the new laboratory for molecular biological studies at the CRI through CESS assistance was nearly completed. A rapid expansion in molecular assay procedures for development of molecular markers and diagnosis of pathogens of unknown etiology in coconut is expected after the laboratory is equipped. The work on FAO assisted project for diagnosis of Rapid Decline Syndrome has already been commenced in collaboration with Plant Physiology and Plant Protection Divisions.

2.3 Soils and Plant Nutrition Division

The research programme of the Division was aimed at refining technology on nutrient management, particularly with locally available organic and inorganic materials, evaluating micronutrient requirements and developing irrigation techniques for coconut. During the year, the Division maintained sixteen on-going field experiments and commenced one new experiment.

The comparison of the effect of Eppawela Rock Phosphate (ERP) with that of Imported Rock Phosphate (IRP) and Triple Super Phosphate (TSP) on performance of young palms for a ten-year period showed that there was no significant difference in the phosphorus status of the palms among treatments. It implies that ERP can be acceptable as a phosphate fertilizer for young palms.

Substitution of the muriate of potash treatment with sodium chloride for coconut palms on lateritic soils of Wayagolla estate in the Wet zone resulted in a significant drop in the coconut yield after 4 years of continuous application. However, there was no effect on the coconut yield or the nutrient status of the palms on loamy sand soils of the Dry-Intermediate region due to the above substitution. According to the experiment conducted at Ganewatta estate, it showed that coconut palm on lateritic soils responds to sodium chloride and muriate of potash treatment due to the iron exchange properties associated with is clay fraction. An experiment at Bandirippuwa Estate showed that the toddy yield of palms increased due to ethrel application on the flower along with regular application of fertilizer.

An experiment on application of poultry manure to the coconut palms showed that fresh poultry dung is harmful to coconut roots in the surface layer. An experiment on drip irrigation conducted on lateritic soils at Ratmalagara Estate was continued. The yield data of this year showed a nut yield increase of 47% in drip irrigation treatment at 43 liters of water per day per palm. Some experiments showed that soil physical properties were significantly ($p \leq 0.01$) improved by application of organic amendments such as goat dung, cow dung and Gliricidia.

During the year, the Division provided Differential Fertilizer Recommendations (DFR) to 138 growers, quality test reports for 182 inorganic fertilizer samples, 13 organic manure samples and 200 coir dust samples and soil survey data for 1000 ha of coconut lands. Compared to the previous year, the grower response to DFR remained more or less the same in the current year also. The staff carried out thirty advisory visits and participated in four training programmes.

2.4 Crop Protection Division

The research programme of the Division mainly focussed on developing and refining the management strategies for major pests and diseases.

Studies on determining optimum trap density for mass trapping of red weevil were completed. It was observed that a decrease in trap density from the current recommendation of six traps per hectare would reduce the number of weevils trapped. Therefore, the recommended trap density cannot be reduced without a loss of efficiency. A new experiment was initiated to identify alternative food sources to replace toddy in the pheromone trap.

Experiments on the parasitoids, *Brachymeria nephantidis* and *Eriborus trochanteratus* continued to show satisfactory results in controlling coconut caterpillar in different climatic regions. One release of each parasitoid at a rate of 1 to 500 of the pest reduced the population by over 95% within three months.

Population dynamics of parasitic nematodes in the roots and soils of leaf scorch decline palms were studied throughout the year. A high incidence of parasitic nematodes in roots of affected palms was found in December, while none were associated with the roots in other periods. However, parasitic nematodes were present in the soil throughout the year.

Observations on the *Ganoderma* root and bole rot disease were continued in the Southern Province. It was clearly evident that seedlings planted in vacancies left by death of Ganoderma affected palms, do not get the infection up to three years.

The investigation on the effect of Oxytetracycline on Leaf Scorch Decline palms was continued. A positive effect on suppression of LSD symptoms was shown when Tetracycline was applied. Studies are being continued to determine the effect of Topsin, Nemacur, and Oxytetracycline on rapid decline palms as well.

Aceria coconut mite out-breaks were reported in new areas such as Polonnaruwa, Anuradhapura, Jaffna, and Kurunegala. The details of the mite control programme is reported under outside funded projects.

2.5 Plant Physiology Division

The highest priority was given for research on disorders of unknown etiology. 'Coconut Rapid Decline' (CRD) affected palms were treated with micronutrients, common salt, nematicide, fungicide, and Oxytetracycline and the progression of the symptoms was monitored for eighteen months. Recovery of palms could not be seen. With the assistance of the Food and Agriculture Organization (FAO), a project was launched for molecular pathogen diagnosis. Under this project, Dr. Lalith Perera, RO/GPB received three month training in the Adelaide's University under the guidance of Dr. Johu Randles to familiarize the molecular pathogen diagnosis techniques.

It was observed that Zn content in the 14^{th} leaf was lower in Leaf Scorch Decline (LSD) affected palms compared to apparently healthy palms. Therefore, LSD affected palms at Bandirippuwa and Walpita estates were root fed with 100ml of 1% $ZnSO_4$ solution and observations were made for a period of one year to determine the effect of Zn on expression of symptoms. Recovery of affected palms was not observed.

Physiological performance of CRIC 60, CRIC 98, and CRIC 65 seedlings grown under plant house conditions, and adult palms grown in the field, at three moisture regimes was evaluated. There was a significant difference in the photosynthesis, water potential rate of transpiration, stomatal diffusive resistance, and water-use efficiency of palms in all three varieties, both in the plant house and in the field, irrespective of the severity of stress.

The patterns of embryo sac development and the epidermal cell growth of the outer skin (exocarp) during fruit enlargement, from female flower to mature nut, were studied. The outer skin of fertilized nut consists of large numbers of small, thin walled epidermal cells. The elongation and expansion of these cells started at the second month and fifth month respectively after fertilization and continued up to ninth month stage. The embryo sac could be seen two months after fertilization and it increased in volume up to ninth month, showing the highest rate of increase during the fifth to ninth month period.

2.6 Tissue Culture Division

Twenty tissue cultured coconut plants were planted at Bandirippuwa Estate, Daisy Valley Estate and Lenawa Estate to evaluate their performance in the field. The growth of tissue-cultured plants established previously at Bandirippuwa Estate was found to be satisfactory. Twenty more tissue-cultured plants were fully acclimatized and are ready for field planting.

Several plant regeneration protocols were tested for *in vitro* somatic embryogenesis from plumule-derived callus. Application of 5.0 uM ABA for 5 weeks resulted in consistent plant regeneration at a low frequency (4.4%). The effect of high agar-induced moisture stress, different cytokinins and $AgNO_3$ (at different concentrations) in combination with ABA on somatic embryogenesis and plant regeneration was assessed. Water stress induced by high agar concentration significantly increased the frequency of somatic embryogenesis (62.1%) and plant regeneration (9.0%). The effect of cytokinins varied with the type and concentration whereas the effect of $AgNO_3$ depended on the concentration. Application of cytokinin in combination with ABA showed a tendency for multiple shoot regeneration.

Preliminary studies on developing a molecular marker of embryogenesis were conducted. Expression of Retinoblastome (Rb) gene (a cell cycle controlling gene) in embryogenic and non- embryogenic callus was studied using ddRt-PCR technique. RNA was extracted from plumule-derived embryogenic and non-embryogenic callus. The results revealed that the expression of Rb gene in non-embryogenic callus indicated the possibility of using Rb gene as a marker to screen embryogenic callus.

Preliminary investigations on pollen and ovule culture were initiated, in order to develop the technology for the production of double haploids. The developmental stage of pollen is a critical factor in androgenesis. To develop an external marker for collecting anthers at the correct developmental stage, a study was undertaken to identify any correlation between the age of the spadix in terms of Weeks Before Splitting (WBS) and stage of pollen development in Sri Lanka Tall coconut under local environmental conditions. The study showed that the late uninucleate stage (which is reported as the most suitable stage for embryogenesis) could be obtained from 3 WBS spadices, while it is shortened by one week during severe drought conditions.

Investigations on cryo-preservation of mature zygotic embryos of coconut were initiated. Three protocols were tested with different methods of desiccation. The best recovery rate (60%) of embryos was achieved by the combined effect of 10h desiccation of embryos by silica gel followed by pre-treatment in 600 g l-1 glucose and 15% glycerol for 15 h.

2.7 Biometry Division

The Division continued to assist the research divisions in designing field experiments and field surveys, socio-economic surveys, statistical analysis, and database management.

The calibration trial at Walpita Estate recorded a 2.4% decrease in the total number of bunches as compared to year 2000. The number of nuts per hectare recorded was 12498 as against 13710 in 2000. The copra yield was 2757 kg/ha as against 3013 kg/ha recorded in 2000.

2.8 Coconut Processing Research Division

During the year, attention was focussed on value addition of coconut oil, development of coconut based value-added products, and on minimising wastage of coconut milk/cream during the extraction process.

A study was carried out to compare the stability of other vegetable oils and coconut oil during deep-frying. The results revealed that crude coconut oil is stable even at high temperatures, when compared with other vegetable oils with added antioxidants available in the market. When blended oils were used, peroxide value of blended oils increased, when used for deep-frying.

Microbial contamination of coconut milk and coconut oil extracted from sun-dried and oven-dried scraped coconut was examined, using the domestic coconut oil extractor introduced by the National Engineering Research and Development Centre (NERD). No significant difference in microbial growth was observed in coconut oil/ milk extracted from sun-dried or oven-dried grated coconut.

Yoghurt was prepared using coconut milk as the main substrate. The setting quality of yoghurt was improved by partial de-fatting of coconut milk by centrifugation. Similarly, good quality ice cream was prepared with coconut milk and non-fat milk powder in the ratio of 1:1. Coconut milk extracted from dikiri coconut gave similar results.

A study was commenced to develop a method to extend the self-life of grated coconut. The pH and water activity of fresh coconuts was found to be 6.2 and 9.9, respectively. Different acidulants and humactants were examined to reduce pH and water activity of coconut up to the safety level, without affecting organoleptic properties.

Sixteen yeast strains were isolated from fermenting coconut toddy. Amongst these wild strains, one isolated strain gave 9.4% ethanol concentration when unfermented sap was inoculated as against 5.62% with indigenous population. Addition of 100-150 ppm sodium metabisulphite further improved the ethanol concentration on the fifth day of fermentation.

2.9 Extension Services Division

The Division continued to assist growers by continuing technology transfer programs, skill development of supervisory staff of estates, and the establishment of linkages between the institute and the growers.

As in the previous year, seven one-day training programs were conducted during the year covering important topics to improve production in coconut lands. The total participation was 670. In addition to the one-day training programs, several training programs were conducted for trainees from NIPM, Extension staff of CCB, and officers from different agricultural organizations.

It has been observed that one of the major reasons for poor adoption of technologies in medium and large estates is due to poor on-farm management and, lack of trained staff for management of estates. To help fill this gap, the Institute commenced an intensive training programme for a batch of 25 GCE (AL) qualified youth. Several seminars, field days, and educational programs were conducted for the benefit of different stakeholders of the industry to improve their knowledge in coconut cultivation and processing.

A progressive increase in the number of visitors to the Division who seek technical advice in respect of field problems was observed. During the year, nearly 200 coconut growers visited the Division seeking advice on coconut cultivation as against 140 in 2000.

2.10 Library Services Division

Routine services of the library were conducted satisfactorily throughout the year. The number of printed books added to the collection was 43. The total number of books were 5622 books at 31 December 2001. Literature searches were made on the coconut database to cater to the information needs of staff as well as outsiders. Library opening hours were extended with a view to improving utilization of resources and for the convenience of staff.

Selective dissemination of content pages of journals continued to be the major resource sharing activity provided at institutional level. Under this service, content pages of 170 journals received from outside libraries were supplied to staff members. The library supplied content pages of 68 journals to other libraries under the same service.

2.11 Estate Management Division

The Division continued to manage four seed gardens and four research substations, covering a total extent of approximately 1197 hectares. The newly acquired Pallama Seed garden is under development and an extent of approximately 50 hectares have been already planted with hand pollinated *San Ramon* and *tall x tall* Ambakelle seedlings. This seed garden is developed with the objective of mass production of *tall X San Ramon* (CRI SL 98) seedlings for the national replanting program. The Coconut Development Authority (CDA) handed over Dunkannawa Estate, having an extent of 10 ha, to the CRI on a long-term lease. This estate will be developed as a model garden/demonstration farm for the growers.

The total yield of all eight estates during the year was 5,591,431 nuts, produced by 74059 bearing coconut palms and 4391 partially bearing palms. A 3% increase in nut yield was recorded compared to the previous year. However, the drought that prevailed after the second quarter of the year, resulted in decline of the nut yield by about 30% in some estates, below the estimated figure.

The total seednut production for the National Replanting Programme from Ambakelle and MaduruOya seed gardens was 1,366,165 nuts. Further, plus palm

nuts were selected from identified blocks of CRI estates. The entire seednut supply during the year increased by 13%, compared to the previous year. All the estates received low rainfall with poor distribution, compared to the previous year. Due to this reason, more attention was directed to soil water conservation practices to alleviate drought damage. All young plantations were provided with a thick mulch and a regular schedule of irrigation was followed. Despite these efforts, it was observed that some dwarf plam blocks were severely affected in Ambakelle and Poththukulama estates, probably due to heat stress. The crop of the 5th and 6th picks declined in all estates due to the drought.

2.12 Administration Unit

During the year 06 Executive and 11 Non Executive positions were filled. At the end of 2001, there were 362 employees on the permanent staff of the CRI. Regular staff meetings were held to discuss the implementation of the work program for the year 2001. Every attempt was made to maintain good employer - employee relationships and the Division continued to assist in all welfare activities.

The budgeted expenses during the year were Rs.144.6 million made up of 104 million as recurrent and 40.6 million as capital expenditure. The total revenue for the year was Rs.35 million. The Government grant was Rs.76.2 million.

The Board's contribution to the Medical Aid Scheme was 2,684,442.04 The Board continued to extend financial assistance to the Seva Vanitha Unit, Co-operative Society, Recreation Club, Art Circle and Day Care Centre run by the Institute.

The Engineering Unit carried out maintenance of buildings, electricity supply, vehicles and machinery.

3. OUTSIDE FUNDED PROJECTS

3.1 Cess Funded Projects:

Project Title : Persuasive Extension Program
Division : Extension Services Division

During the year, 48 estates were inspected and estate development plans were submitted covering an extent of 2100ac. Development activities of 25 estates were monitored and it was observed that landowners have implemented around 60% of the proposed activities in their farm development plans.

Project : Control of coconut mite *(Aceria guerrerinis)*
Division : Crop Protection Division

Coconut mite infestations were reported from Mannar, Pollonnaruwa, and a few areas in the Kurunegala District. Control measures were advocated promptly to prevent further spread of the infestation.

The study on the seasonal population pattern of *A.guerreronis* and predator *Neoseiulus paspalivorus* was continued at three sites. The trend in fluctuations of the populations over time was similar to that of previous years. The population of *A. guerreronis* peaked in July-August, June –September and August –September in Kalpitiya, Madurankuliya and Vanathavillu respectively. The predator population also followed a similar trend in Vanathavillu.

Efficiency of three neem based products i.e.ethanolic extract of neem seed kernels, 2% neem oil, garlic and soap mixture, and Nomite plus a commercial formulation of neem oil and garlic was compared under laboratory conditions using mite colonies on tender leaf tissues. Two percent neem oil and garlic mixture yielded the highest mortality of 88.1%. The mortality of neem seed kernel extract and Normite plus was 66% and 55% respectively.

Project : Studies on the retting process of coconut fibre to improve the quality of coir fibre
Division : Coconut Processing Research Division

The objective of this study is to identify microorganisms present in fresh water, brackish water, and saline water retting pits and to establish an artificial microbial consortium to accelerate the retting process. Ret liquor was collected from eight sampling sites and microorganisms present in the liquor were isolated. The predominant organism in all three types of water was found to be a spore forming Bacillus. Among the fungi, Mucor and Aspergillus was found to be the commonest.

Project : Investigation of causative agents of coconut diseases using molecular biological techniques and transmission electron microscopy funded by CESS.

Most of the equipment and chemicals specified under this project have been purchased. Two research officers are undergoing training leading to Ph D on molecular diagnostics for which assisstance is partly provided through this project.

3.2 IFAD (COGENT)

Coconut embryo culture research to develop effective technology for the production of coconut seedlings from the high-value soft-endosperm coconut variety "Dikiri Pol"

Principal Investigator: Dr L K Weerakoon

3.3 Food and Agriculture Oraganization (FAO)

Assistance to identify the causal agent of Coconut Rapid Decline and to initiate a practical disease control strategy

Project coordinator- Dr C S Ranasinghe

Main objective of this study was to determine whether a phytoplasma, virus or viroid is associated with coconut rapid decline syndrome. The presence of phytoplasma in affected palma were tested using nested polymerase chain reaction. The PCR studies have so far given positive signals for one "diseased" palm and further studies are being continued.

Council for Agriculture Research Policy (CARP) Grants

3.4 National Research Council Grant

1. Culture of immature inflorescence explants of coconut *(Cocos nucifera* L.) with a view to clonal propagation
   Investigator- Dr L K Weerakoon Value of the award- Rs 2,086,700/=
2. Cell suspension and protoplast culture of coconut (*Cocos nucifera* L.) for mass propagation of elite palms
   Investigator- Ms W N I S Fernando Value of the award- Rs 2,337,500/=
3. Molecular diagnosis of coconut disorders, leaf scorch decline syndrome (LSD), rapid decline syndrome (RDS), and premature decline syndrome (PDS) of unknown etiology.
   Investigator- Mr J M D T Everard Value of the award – Rs 1,000,000/=

3.5 ADB funded Science and Technology Personnel Development Project

1. Development of molecular markers for defining bio-diversity and its use in marker assisted breeding in coconut.
   Two postgraduate scholarships are in progress. Overseas consultancy for tissue culture was completed. Among the many items requested for research, gas liquid chromatograph, variable wave length detector for the HPLC, thermocycler and a heat block incubator have been received.

2. Development of coconut kernel based food products.
   Two postgraduate scholarships are in progress. Kernel product development activities are being continued with the assistance of Prof. Samarajeewa, Consultant to Coconut Processing Research Division.

3.6 Center for Climatic change studies funded by CCCS through NSF

Impact of climate change on national coconut production. This study is being carried out to identify climate change scenarios in low country wet intermediate region and the interaction with coconut production.

Investigator- Dr T S G Peiris Value: Rs 440,000/=

4. ACKNOWLEDGEMENTS

The co-operation extended by the Deputy Director (Administration and Finance), Heads of Divisions and Staff of the Coconut Research Institute in successful implementation of the program of work is gratefully acknowledged.

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

Continued support given by the following organizations is also acknowledged:

* Ministry of Plantation Industries
* 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
* National Research Commission (NRC)
* Export Development Board
* Medical Faculty, University of Colombo
* Department of Botany, University of Peradeniya
* Postgraduate Institute of Agriculture (PGIA)
* Industrial Technology Institute (ITI)
* National Science & Technology Commission (NASTEC)
* Sri Lanka Institute of Development Administration (SLIDA)
* Institute of Government Accounts and Finance Planning (INGAF)
* Kurunegala Plantations Ltd.
* Central Plantation Crops Research Institute, India
* Indian Council for Agricultural Research
* Coconut Genetic Resources Network
* Asian and Pacific Coconut Community, Indonesia
* International Service for National Agricultural Research (ISNAR)
* International Mycological Institute, UK
* Postgraduate Institute of Science (PGIS)
* Australian Tree Seed Centre
* GTZ/CARP Project
* ADB funded Science & Technology Personnel Development Project
* ADB & Second Perennial Agricultural Project
* Food & Agriculture Organization (FAO)

REPORT OF THE AGRONOMY DIVISION
Head - H A J Gunathilake, PhD

1. SUMMARY

During the year much emphasis was given to research on soil moisture conservation in coconut lands in different suitability classes as well as to increase productivity of coconut lands through intercropping and animal husbandry. Socio-economic studies on analysis of the impact of price policies on the domestic coconut industry and a preliminary analysis on the distillery industry and coir industry revealed valuable information useful for coconut policy changes.

The annual rainfall was declined during the year in many coconut-growing areas. Experiments conducted to determine the moisture conservation practices such as husk burial and mulching on land suitability classes designated as S_3, S_4 and S_5 lands maintained higher coconut yield despite the drought. Mulching with husk was the most effective in S_3 and S_4 lands.

Studies on the rehabilitation of low yielding palms in degraded coconut soils (IL_1/S_5) showed that coconut seedlings planted in 1.3 m x 1.3 m x 1.3 m holes and 1.3 m x 1.0 m trenches reached the flowering stage earlier than those planted in 1.0 x 1.0 x 1.0 m. The comparison of five ground covers on coconut yield gave no significant results due to the severe drought prevailed during the year.

Application of Glyphosate (4 l/ha) was more economical and effective for control of weeds in coconut lands than cover-cropping, cattle grazing, slashing with two-wheel tractor or inter-cultivation of gliricidia. Glyphosate of four concentrations (1,2,3 & 4 l/ha) were tested to control weeds in coconut nurseries. Even the highest concentration of glyphosate did not affect growth of seedlings while controlling weeds effectively even at lower concentrations.

The bud-grafted cashew continuously showed better performance than the seedling or the air layered cashew and coconut yield was not affected by inter-planting of cashew. Bud-grafted cashew yielded 4.2 kg/tree during the year. Rehabilitation of coconut soils with Mana grass prior to planting tea in coconut lands is being carried out at Galle and Matara districts.

The coconut based adaptive research program funded by the ADB through the Second Perennial Crop Development Project is being continued in 112 sites in 15 administrative districts and found to be an effective tool in transferring technologies on coconut based farming systems. While popularizing intercrops such as pepper, pineapple, banana, rambutan etc, special emphasis was given to expand cultivation of cinnamon in the wet zone and grafted cashew in the intermediate and dry zones.

Under the animal husbandry program, research on a low cost poultry production system received high priority. Three crosses/strains of chicken (Indigenous, CPRS x Indigenous and CPRS (Karadagolla) are evaluated to determine the production and adaptability to a restricted scavenging system in

coconut land with supplementation of a formulated ration. Initial results showed that CPRS was superior to other two.

Analysis of the impact of several price policy instruments on the coconut sector indicated that coconut cultivation subsidy has a significant positive impact on the total national coconut production with a 13 years lag on the initial investment. Further, this study showed that the protection in the edible oil market with a high tariff rate allows marginal increases in the domestic coconut oil supply, while creating unfavorable impact on coconut oil consumers. In another socio-economic study, the possibility of the enhancement of the toddy tapping industry through the promotion of the coconut-based arrack industry was investigated. This study revealed that arrack price, beer price and consumer income were the significant variables, which would determine the arrack consumption in the country. Hence, there is a promising potential of enhancing the coconut-based arrack consumption through a slight manipulation of the tax rate of arrack.

2. RESEAERCH PROJECTS

PROJEECT 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_2), 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 2001, root pruning by disk harrowing (15 cm depth) and application of 3.0 kg of APM + 1.0 kg of dolomite/palm were continued according to treatments given in Table 1.

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

Treatments	Nuts/palm/year		
	1997 - 2000	2001	% Difference of nut yield reduction 2000-2001
Control (no fertilizer + no harrowing)	40	13	72
Harrowing + Fertilizer	48	28	50
Harrowing only	44	24	53
Fertilizer only	47	33	35
Significance		*	
LSD (P=0.05)		12	

Results show that either harrowing or fertilizer applications improved nut yield over control (Table 1). However, fertilizer application followed by harrowing failed to establish a positive interaction between two operations on improvement of nut yield.

It is worthwhile to further investigate reasons for improvement of nut yield only by harrowing.

The experiment is in progress.

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_6), Madampe -1997

The objective of this experiment is 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 Randomised Complete Block Design with three replicates. There are nine effective palms per plot.

No significant difference in growth of seedlings in terms of number of leaves and height were observed during the year. However, the overall performance of seedlings was satisfactory despite the long drought period prevailed last year. The experiment is in progress.

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

	Treatments	Number of leaves produced	Plant height (m)
T_1	1x1x1 m pit (standard planting hole)	4	3.9
T_2	1.3x1.3x1.3 m, pit (filled with husk/same soil)	5	4.2
T_3	1.3x1.3x1.3 m pit (filled with husk/soils brought from out side)	5	4.3
T_4	1.3m wide x 1.3m deep trench (filled with husk/same soil)	4	4.4
T_5	T_4 + 20% increased standard density of palms (156/ha)	5	5.8
Significance		n.s.	n.s.
CV%		15.9	20.1

N A K de Silva, H A Abeysoma, I M Thilakaratne and W A Hemawardane

Experiment 2.4.4: Effects of deep loosening of lateritic soils on the performance of coconuts grown on Andigama Soil Series (Shallow Phase) at Ratmalagara Estate (IL_1/S_4), Madampe - 1997

The study aimed at deep loosening of shallow lateritic soil by mechanical and biological means in order to facilitate better growth of coconut roots thereby increasing growth and yield of coconut. The treatments given in Table 3 were arranged in a Randomized Complete Block Design with three replicates and nine effective palms per plot.

This year too, there was no significant effect of treatments on nut production. Further, the treatment effects were found to be non significant in terms of height increment, girth at the crown and density of roots sampled at 90 cm and 180 cm distance from the base of the palm at 0-50 cm and 50-100 cm depths respectively. However, the nut production of the whole experimental block is on the increase after imposing the treatments (Table 3). The treatment effects may probably have masked due to climatic effects.

Table 3. *Effects of loosening of sub-soil on the production of coconuts on Andigama Series (shallow phase)*

Treatments	Nut yield (nuts/palm)		
	1999	2000	2001
T_1 - Control (General estate practice)	47	70	65
T_2 - 1.3 x 1.3 m trench cut along coconut rows (and filled with same soil)	46	70	60
T_3 - 1.3 x 1.3 m trench cut along coconut rows (and filled with soils from out side)	45	63	71
T_4 -1/3 circular trench cut around the manure circle (and filled with same soil)	50	60	60
T_5 - Inter-cultivation of *Gliricidia*	51	65	68
T_6 - Inter-cultivation of *Acacia*	51	63	67
Significance	n.s.	n.s.	n.s.
CV%	45	32	16

N A K de Silva, H A Abeysoma,
I M Thilakaratne and W A Hemawardane

Experiment 2.4.5: Rehabilitation of degraded coconut soils through short term forestry in Andigama. Soil Series (Shallow phase) at Ratmalagara Estate (IL_1C_0), Madampe - 1999

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

Among the tree species under study, *Acacia mangium* provenances showed a higher growth rate as in the previous year (Table 4). In addition, these two provenances had the highest leaf litter production, which can be assumed to improve soil physical as well as bio-chemical properties when decomposed. *Macaranga paltata* followed by *Acacia auriculiformis* and *Gliricidia sepium* were also showed their potential benefits as fast growing forest tree species. However, impact on soil properties by these tree species has not been shown yet as measurements on soil organic matter and moisture contents as well as bulk density were found to be not significant by different among treatments. The experiment is in progress.

Table 4. *Growth and leaf litter production of forest tree species*

Treatments	Leaf litter DW (g/m2)	Diameter at base (cm)	Diameter at breast height (cm)
T_1 - *A. auriculiformis*	92^{c}	7.4^{bc}	6.4^{c}
T_2 - *A. mangium-1*	327^{ab}	10.1^{a}	8.9^{a}
T_3 - *A. mangium-2*	488^{a}	10.3^{a}	9.2^{a}
T_4 - *Calophyllum elatum*	27^{c}	2.5^{f}	1.8^{f}
T_5 - *Grewia tilifolia*	57^{c}	1.6^{f}	1.5^{f}
T_6 - *Macaranga paltata*	188^{bc}	8.9^{ab}	7.7^{b}
T_7 - *Gliricidia sepium*	156^{bc}	5.8^{cd}	5.0^{d}
T_8 - *Tectonia grandis*	175^{bc}	3.1^{ef}	2.4^{ef}
T_9 - *Swietenia macrophylla*	90^{c}	3.3^{ef}	2.2^{ef}
T_{10} - *Bridelia moonii*	120^{c}	5.0^{de}	3.4^{ef}
Significance	**	***	***
CV%	47	14	10

Means with same letter are not significantly different at P=0.05

N A K de Silva, H A Abeysoma and P Pieris

Experiment 1.0.3.6: Competition of pasture on the growth and yield of coconuts on Andigama Series (Shallow Phase) at Ratmalagara Estate (IL1/S4-5), Madampe - 1997

This experiment investigates the effects of different ground cover management systems on the performance of coconut palm and soil palm water relations on degraded shallow lateritic soils. the treatments given in Table 5 were arranged in a Randomized Complete Block Design with three replicates.

There was no significant effect of treatments on nut yield during the year. It can be assumed that the treatment effects would have been masked due to the drought prevailed during the second half of the year. This is quite evident from the decreased nut yields as compared to the previous year (Table 5). However, regardless of the non-significance of treatment effects, palms in plots having coir dust mulch produced the highest number of nuts during the year.

Measurements on palm water relations as affected by different ground cover treatments has been done by the Plant Physiology Division and is recorded in the latter part of this report.

The experiment is in progress.

Table 5. *Effects of ground covers on coconut yield*

Treatments	Number of nuts/palm/year		
	1999	2000	2001
T_1- Bare ground	60	70	66
T_2- Controlled grass cover (*B. brizantha*) (slashing 4 times a years)	41	70	65
T_3- Uncontrolled grass (*B. brizantha*) cover	43	71	58
T_4- *Pueraria* cover (live mulch)	50	85	67
T_5- Coir dust to a 5.0 cm depth (dead mulch)	69	97	79
Significance	n.s.	*	n.s.
CV%	33	25	22
LSD (P=0.05)		8	

P W A Fernando

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

Experiment 3.3: Study of 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
3.3.4 Bingiriya (IL_1/S_4) - 1997

Effects of various methods of husk burial and mulching (Table 6) are being tested on a RCBD with three replicates with nine effective palms per plot.

During the year, a severe drought prevailed in the coconut triangle, which resulted in declining average annual rainfall by 33%

Up to the year 2000, nut yield of palms with different methods of husk burial and mulching did not show consistent differences. In contrast to previous years, several methods of husk burial and particularly husk mulching showed significant improvement on nut yield in three sites except, Pallama (S_2 soil class) (Table 5, 6, 7, 8 and 9).

Mulching with husks showed the highest nut yield improvements at Minuwangoda, Hettipola and Bingiriya sites. Mulching reduced soil temperature significantly as given in Table 7. Reduced temperature is likely to be beneficial on root function. Generally, mulching either with fronds or husk showed beneficial effect except at Pallama site. Among different methods of husk burial, 2.6 x 1.3 x 1.0 m pits between two palms gave the best results.

Table 6. *Coconut yields (nuts/palm/year) as affected by different methods of husk burial and Mulching*

Treatments	Minuwangoda		Hettipola		Pallama		Bingiriya	
	97-2000	2001	97-2000	2001	97-2000	2001	97-2000	2001
T_1 - Control(Standard practices)	40	45	42	46	50	46	47	46
T_2 - Mulching with 12 fronds	42	57	45	53	44	49	48	54
T_3 - T_1+1/3 circle trench filled with same soil	43	52	31	50	43	41	46	45
T_4 - T_1+1/3 circle trench filled with husk	46	48	38	55	44	47	43	53
T_5 - Mulching with husks	46	61	39	59	40	55	49	61
T_6 - T_4 + T_5	47	53	38	53	42	55	47	60
T_7 - 1.3 m x 1.0 m trenches	45	55	37	51	36	51	47	61
T_8 - 2.6 x 1.3 x 1.0 m husk pits between palms	48	57	38	57	39	54	52	56
T_9 - 1.3 x 1.3 x 1.0 m husk pits	44	50	38	52	37	52	46	44
Significance		*		*				***
LSD (P=0.05)		10		7				6

Table 7. *Effect of mulching on soil temperature*

Treatments	^0C	
	at 12.00 noon	at 14.00
No mulch	41.4	44.6
Frond mulch	33.3	35.2
Husk mulch	31.5	32.4

Note: measured on 02 August 2002.

Table 8. *The effect of husk burial and mulching treatments on the sensitivity of palms to severe drought at Bingiriya (observed on 25.08.2001)*

Ranking - 0 - dead
1 - Severely affected
2 - Moderately affected
3 - Not affected

Treatments	No of Functional green fronds	Rank
T_1 - Control (standard practices)	12	2.07
T_2 - Mulching with 12 fronds	17	2.75
T_3 - T_1 + 1/3 circle trench filled with same soil	12	1.98
T_4 - T_1 + 1/3 circle trench filled husk/soil	14	2.41
T_5 - Mulching with husk	18	3.00
T_6 - T_4 + T5	11	1.99
T_7 - 1.3 x 1.0 m trenches	13	2.24
T_8 - 2.6 x 1.3 x 1.0 m husk pits between palms	18	2.86
T_9 - 1.3 x 1.3 x 1.0 m husk pits for each palm	11	1.94

Table 9. *Effect of mulching on immature nut fall during the drought prevailed in July - September, 2001*

Treatments	Immature nutfall/palm (two months period)	
	Minuwangoda	Bingiriya
No mulch	4	6
Frond mulch	2	3
Husk mulch	1	2

The experiment is in progress.

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PROJECT 4: DEVELOPMENT OF A LOW COST MANURING SYSTEM FOR COCONUT UTILIZING ORGANIC/GREEN MANURE

Experiment4.3: Effect of Inter-planting of *Gliricidia sepium* and *Acacia auriculifomis* under coconut and use of loppings for substitution of inorganic nitrogen for coconut palms

Experiment : The experiment is conducted at the following sites.

Location	Soils	Agro-Climate	Land suitability	Year of Commencement
4.3.1:Pottukulama Research Station, Pallama	**Welipelessa Series (alluval)**	**IL_3**	**S_2**	**1995**
4.3.2:Nilpanagoda Estate	**Boralu Series**	**WL_3**	**S_4**	**1996**

The objective of this experiment is to investigate whether the practices of inter- cultivation of nitrogen fixing trees with coconut and use of loppings for green manuring are feasible for substitution of inorganic nitrogen requirement for coconut and for reducing the fertilizer cost. Treatments given in Table 10 were tested at the two sites given above, representing different soil classes and agro-ecological conditions, on a RCBD with three replicates at each site.

This year too, the effect of NFT species and their planting densities on coconut yield has not been significant (Table 10). The nut yield of all treatments including the control at Nilpanagoda site has improved compared to previous year whereas it has been more or less similar in both years at PRS. This could be due to the better rainfall distribution,at Nilpanagoda in which overwhelmed the soil class effect as against at PRS where soil effect could be much prominent.

As in the previous year, Acacia produced a higher foliage biomass than Gliricida at both sites. The production of biomass at PRS was higher than that of Nilpanagoda (Table 11). Further, Acacia planted at the density of 24 trees per coconut square produced significantly a higher foliage biomass yield without affecting the yield of coconut palms. However, there was no significant difference in foliage biomass of Gliricidia planted at two densities.

The experiment is in progress.

Table 10. *Effect of NFTs on coconut yield (nuts/palm/year) at two different sites*

Treatments	PRS			Nilpanagoda		
	1999	2000	2001	1999	2000	2001
T_1- Control (APM + standard practices)	88	82	84	31	45	59
T_2- Gliricidia density 1 (16 trees/coconut square)	68	81	75	28	42	54
T_3- Gliricidia density 2 (24 trees/coconut square)	76	86	80	34	44	44
T_4- Gliricidia density 2 (pruning buried)	88	92	87	33	38	59
T_5- Acacia density 1 (16 trees/coconut square)	69	81	81	26	39	38
T_6- Acacia density 2 (24 trees/coconut square)	64	90	78	28	41	60
Significance	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
CV%	20	19	9	18	18	20

Table 11. *Biomass yield (MT/ha/year) of legume trees*

Treatments	Potthukulama			Nilpanagoda		
	Wood	Foliage	Total	Wood	Foliage	Total
T_2	12.5	4.1	16.5	7.8	3.0	10.8
T_3	11.1	5.5	16.6	8.5	3.4	11.9
T_4	11.6	5.9	17.5	8.9	3.7	12.6
T_5	7.3	13.2	20.5	5.0	10.2	15.2
T_6	8.7	15.1	23.8	6.2	13.7	19.9
Significance	*	**	*	n.s.	***	*
CV%	18.6	21.4	20.2	25.7	16.6	19.1
LSD (P=0.05)	3.9	2.1	2.9		2.1	5.1

N A K de Silva, H A Abeysoma, M J I Costa, W R O Fernando and Y M Chandrasiri

Experiment 4.6: Optimising biomass productivity of *Gliricidia sepium* under Coconuts - Ratmalagara Estate (IL_1/S4), Madampe; Andigama Series (Moderately Shallow Phase) - 1999

The objective of this experiment is to optimise wood as well as foliage biomass by employing three different pruning frequencies viz. 6 months, 12 months and 18 months.

This year too, the results confirmed that the six monthly pruning was capable of producing a higher biomass yield than pruning at twelve and eighteen months intervals with a higher foliage/wood ratio (Table 12). Foliage biomass obtained from eighteen months pruning was relatively high compared to twelve months pruning but there was no significant difference in stem yield between two treatments. This was mainly because of regeneration of foliage after leaf senescence during the drought.

The experiment is in progress.

Table 12. *Fresh Biomass yield (MT/ha/year) of Gliricidia as affected by different pruning regimes*

Pruning frequency	Foliage biomass	Stem yield	Foliage/Wood ratio
T_1 - 06 months	10.6	22.8	0.47
T_2 - 12 months	4.7	19.5	0.24
T_3 - 18 months	7.9	18.9	0.42
Significance	***	n.s.	
CV%	11.8	12.9	
LSD (P=0.05)	1.6		

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I M Thilakaratne and W A Hemawardane

PROJECT 5: DEVELOPMENT OF LOW COST WEED MANAGEMENT SYSTEMS FOR COCONUT LANDS AND COCONUT NURSERIES.

Experiment 5.1: Comparison of several recommended cultural practices for weed management in coconut lands

5.1.1 Pallama Seed Garden (IL_1/S_4)
5.1.2 Ussawa Division, Melsiripura Estate (IL_1/S_3)

Treatments shown in Table 13 were laid on RCBD with three replicates and nine effective palms per plot. During the year, frequent sampling was practiced to understand the dynamics of weed biomass in response to different cultural practices. The major weed species present in these two 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 (only the perennial shrubs are 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 weeds two times per year and mulching
T_5 - Application of Glyphosate at the rate of 4L/ha; two times per year
T_6 - Grazing with cattle 6 times per year

No significant differences in weed biomass production as well as the nut yield were observed among treatments as shown in Table 13 and Table 14.

Table 13. *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	2001 Weed biomass (g/m^2)		
	July	September	November
T_1 - Unweeded control	219	281	216
T_2 - Cover crop (Pueraria)	192	174	212
T_3 - Gliricidia	275	225	148
T_4 - Slashing and mulching	169	154	181
T_5 - Chemical weeding	105	103	244
T_6 - Cattle grazing	232	314	135
Significance (P=0.05)	n.s.	n.s.	n.s.

Table 14. *Nut yield of coconut as affected by the application of different cultural Practices to control weeds at Pallama Seed Garden and Melsiripura estate (at the 2nd year of establishment)*

Treatments	Nuts/palm/year	
	Pallama	Melsiripura
T_1 - Unweeded control	72	46
T_2 - Cover crop (Pueraria)	88	45
T_3 - Gliricidia	77	59
T_4 - Slashing and mulching	78	54
T_5 - Chemical weeding	81	44
T_6 - Cattle grazing	83	58
Significance (P=0.05)	n.s.	n.s.

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

Experiment 5.2. Application of different levels of Glyphosate for weed control in coconut nurseries

5.2.1. Coconut Cultivation Board Nursery - Wilpotha (IL_3)
5.2.2. Coconut Cultivation Board Nursery - Wennoruwa (WL_3)

Controlling weeds is the most laborious and expensive operation in coconut nurseries. In addition, the growth of coconut seedlings is also adversely affected due to competition of weeds. At present, manual weeding and application of Glyphosate and Paraquat are commonly practiced in nurseries. However, no proper recommendation yet available for weed control in coconut nurseries. Further, there is no research evidence on use of pre and post-emergent weedicides too. Therefore, the objective of this experiment was to find an economical rate of Glyphosate application and its impact on coconut seedlings.

Treatments are:

T_1 - Hand weeding
T_2 - Glyphosate 1400g ai/ha (4.0 lit/ha)
T_3 - Glyphosate 1050 g ai/ha (3.0 lit/ha)
T_4 - Glyphosate 700 g ai/ha (2.0 lit/ha)
T_5 - Glyphosate 350 g ai/ha (1.0 lit/ha)
T_6 - Unweeded control

At Wilpotha, treatments were laid on RCBD with three replicates (Table 15). In each plot, 40 seed nuts were laid of which 85% of the seed nuts were germinated. Atawara (*Panicum repens*), Nidikumba (*Mimosa pudica*), Kuweni (*Cenchrus echinatus*), Kurunegala Desi (*Tridax procumbens*) and Landesi (*Amaranthus paniculatus*) were the most dominant weeds.

The plots treated with Glyphosate produced the lowest weed biomass (Table 15). There was no significant difference in weed biomass among Glyphosate treatments. However, its difference in weed biomass between the T2 and the control was highly significant in November and in December. All the weed control showed significantly low biomass production compared to the control (Table 15) at the wennoruwa site.

Table 15. *Weed biomass (g/m^2) at different sampling times as affected by the application of different Glyphosate concentrations at Wilpotha*

Treatments	September	October	November	December
T_1 - Hand weeding	20	103	45	99
T_2 - Glyphosate 1400 g ai/ha	35	265	8	30
T_3 - Glyphosate 1050 g ai/ha	23	136	11	36
T_4 - Glyphosate 700 g ai/ha	20	98	13	26
T_5 - Glyphosate 350 g ai/ha	14	141	17	83
T_6 - Unweeded control	19	156	221	243
Significance	n.s.	n.s.	**	***
LSD (P=0.05)			118	136

Treatments were applied in November

Table 16. *Weed biomass (g/m2) at different sampling times as affected by the application of different Glyphosate concentration at Wennoruwa*

Treatments	*October	November	December
T_1 - Hand weeding	6	60	153
T_2 - Glyphosate 1400 g ai/ha	7	96	169
T_3 - Glyphosate 1050 g ai/ha	4	55	149
T_4 - Glyphosate 700 g ai/ha	5	26	107
T_5 - Glyphosate 350 g ai/ha	9	87	157
T_6 - Unweeded control	12	101	211
Significance	n.s.	n.s.	**

* Seed nuts were layed in September. Treatments were not applied in 2001

At Wennoruwa, dominant weeds were Kalanduru (*Cyperus rotundus*), Nidicumba (*Mimosa pudica*), Kurunegala Desi (*Tridax procumbens*) and Landesi (*Amaranthus paniculatus*). In each plot, 40 seed nuts were laid and 75% of seed nuts were germinated. There were no significant differences between treatments on weed biomass (Table 16).

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PROJECT 19: SMALL HOLDER 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 17 were tested on a RCBD with three replicates. Each plot consisted of nine effective coconut palms.

Grafted and air-layered cashew seedlings showed differences in their canopy form and also in their root distribution. Coconut yield was not affected by the plant type of cashew (Table 17).

During the year, bud-grafted and air-layered cashew yielded 4.2 and 3.4 kg/tree respectively while seedling cashew yielded only 1.6 kg/tree. The yield variation among trees within plots was high. The yield gap between air-layered and grafted cashew was gradually narrowed down with time Growth parameters between the two types also indicated a similar relationship.

The experiment is in progress.

Table 17. *The effect of the plant type of cashew on coconut yield*

Treatments	Coconut yield (nuts/palm/year)	
	1996 - 2000	2001
Coconut monoculture	59	91
Bud grafted cashew	55	79
Air-layered cashew	57	82
Seedling cashew	58	80
Significance (P=0.05)		n.s

b) **Pallama Seed Garden (IL_3,S_2) – 2000**

Among three cashew planting types, 80% and 20% of bud-grafted and air layered cashew respectively flowered during the year. None of the seedling cashew did flower yet.

The cashew plants did not show any effect on coconut yield of planting as given in Table 18.

Table 18. *Coconut yield as affected by intercropping of different planting materials of Cashew*

Treatments	Coconut yield (nuts/palm/year)	
	2000	2001
Coconut monoculture	37	68
Bud grafted cashew	40	71
Air-layered cashew	35	71
Seedling cashew	37	62
Significance (P=0.05)	n.s.	n.s

Experiment 19.4: Studying on a suitable density of grafted cashew in adult coconut plantations - 2001.

19.4.1: Polontalawa Estate, Nikaweratiya (IL_1/S_5)
19.4.2: Galpota Estate, Kuliyapitiya (IL_1/S_4)

Among the intercrops, cashew is popular due to its drought tolerance character, low cost of cultivation and its wide adaptability in coconut lands in the intermediate and dry zones. Research, carried out by the CRI so far, proved that out of the seeding types, grafted cashew is the most suitable plant type to be intercropped in coconut lands. However, proper planting density and plant layout are important for the performance of cashew due to its large canopy. Therefore the objective of this study was to identify suitable planting density and layout of grafted cashew for intercropping in adult coconut plantations.

These two experiments were established on a Randomized Complete Block Design (RCBD) with three replicates and nine effective palms per plot.

Treatments:
- T_1 - Coconut only
- T_2 - Grafted cashew tree per every coconut square (156 trees/ha)
- T_3 - Cashew in alternate avenues of coconut (78 trees/ha)
- T_4 - Cashew in alternate coconut squares (78 trees/ha)

Grafted cashew plants were established in October and nut yield recording was commenced.

The experiment is in progress.

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PROJECT 21: DEVELOPMENT OF SMALL HOLDER COCONUT FARMING SYSTEM WITH LIVESTOCK (CATTLE AND SMALL RUMINANTS) INTERGRATION IN THE INTERMEDIATE AND DRY ZONES

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

This experiment is on a Complete Randomized Block Design (CRBD) with three replicates and 16 effective palms/plot. The site comprises clay loam soils. Three treatments were assigned to manage ground pasture and weed cover they are, (a) slashing by rota-slasher attached to a four wheel tractor as necessary (about 3 rounds per year), (b) *Pueraria* cover cropping and (c) buffalo management (one animal for every 2.0 ha) with rotational grazing on one month cycle.

Table 19 shows that nut yield of buffalo grazed plots was higher than that of plots with cover crops or plot where weeds are slashed. This might be due to addition of nutrients to the soil and reduced competition between coconut and Pueraria or grasses.

Table 19. *The effect of buffalo grazing, cover cropping and slashing on yield of coconut at Makandura*

Treatments	Coconut yield (nuts/palm/year)		Soil Compaction (N/cm^2)
	1999 – 2000	2001	
Slashing	77	84	143
Cover cropping	69	83	117
Buffalo grazing	80	92	172
Significance		*	*
LSD (P=0.05)		6	11

As in previous years, soil compaction in grazed plots was significantly higher than the other two treatment plots (Table 19). Hence, harrowing once a year may be useful to reduce the effect of soil compaction.

Average milk yield of a buffalo was 4.2 l/day during the year, which is an additional income obtained from buffalo rearing.

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

Three pasture varieties were evaluated on farm, in the Low Country Wet and the Low Country Intermediate zones for their suitability for small holders in terms of dry matter (DM) production, adaptability and farmer preference. In the Low Country intermediate Zone, *B. brizantha* showed significant ($P< 0.05$) increase in DM production in comparison to *B.miiliformis* and *B.ruzziziensis* (Fig.01). However, farmers prefer *B.miiliformis* and *B.ruzziziensis* to *B. brizantha as* higher rate of wastage of feed due to hard stems in the case of *B. brizantha.* There was no significant difference in annual DM production between *B.miiliformis* and *B.ruzziziensis* in the Intermediate Zone. The DM production in each month showed (Fig.02) that *B.ruzziensis* out yield *B.miiliformis* during dry months of the year. But the higher DM production of *B.miiliformis* during wet months was higher(compensatory DM production). Therefore results suggest that a mixture of *B.ruzziziensis* & *B.miiliformis* (in the same field but separately) ensures a sustainable feed supply for small holders in the Intermediate zone. Average Crude Protein content of *B.miiliformis, B.ruzziziensis and B. brizantha were* found to be 12.4%, 11.3% and 12.5% respectively during dry period.

Among three varieties, *B.miiliformis* performed well in smallholdings in the Low Country Wet Zone (Fig.01). Data were not statistically analyzed in the case of Low Country Wet Zone due to insufficient replication, as some of the farm models were recently established in the Wet Zone.

Feeding systems in smallholdings could not be followed done as proposed during the year because Gliricidia plants (*Giricidia sepium)* had not grown well due to the prolong drought.

A D Samarajeewa and, M D V Saparamadu

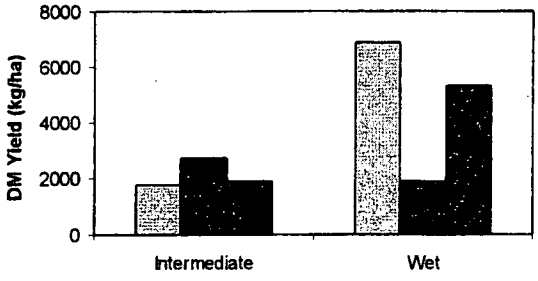

Fig 01. On-farm performances of pasture grasses in different agro-eco zones

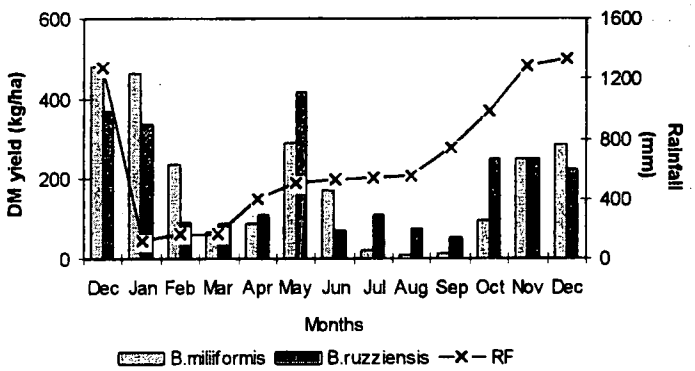

Fig.02 On farm performance of B.miliiformis and B.ruzizziensis in Low Country intermediate zone over the year

Experiment 21.5.2: Goat Farming Demonstration

This was continued during the year. At the end of the year, the herd was increased to 22. These animals will be used as a goat breeding stock for the ADB funded project on "development of sustainable income generating technologies for poor rural communities in Sri Lanka".

A D Samarajeewa and M D V Saparamadu

Experiment 21.5.3: Development of low cost poultry production system in coconut

Three Chicken Crosses/ Strains (Indigenous type, CPRS, CPRS x Indigenous type) were evaluated for "restricted scavenging system" in coconut plantations with the supplementation of formulated ration. One-month-old chicks were introduced to the system in September, 2001. Formulated poultry ration consisted of 14.45% Crude Protein, 2684 kcal/kg metabolic energy, 0.7% Lysine and Methionine + 0.48%Cystine. This was supplemented, irrespective of growth stage, at the rate of half of the feed requirement. Body weight gain in the 20th week was as follows (Table 20).

Table 20. *Live weight gain of chicken strains/ cross in the 20th week*

Strain /Cross	Live weight (g)/bird
Indigenous type	1159 (197)*
CPRS x Indigenous	1245 (203)
CPRS	1276 (123)

- Numbers in parentheses are Standard Deviations

Results showed that CPRS was superior to the other two, in terms of live weight gain in 20thweek with less variation among the birds (Table 20). Cross-between CPRS x Indigenous type performed better than indigenous type.

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D V S de Gamage (Veterinary Research Institute)

Experiment 21.5.4: Formulation of Leaf Meal Protein block for livestock

A Preliminary study was conducted to explore the possibility of developing a "Protein Block" with leguminous tree fodder. Main focus was given for the utilization of excess leaf meal produced in the extensively grown energy plantation (Gliricidia spp., Acacia spp.). If the part of the leaf meal produced in energy plantations can be converted to animal feed, it will not only increase the productivity of energy plantations but also provide high quality protein supplement for ruminant livestock.

Ingredient used for the formulation of block is given in Table 21.

Table 21. *Composition of the Protein- Mineral block*

Block	Ingredients (% by weight)				
	Gliricidia	Acacia	Cement	Molasses	Salt
Gliricidia 100%	45	-	10	40	5
Acacia 100%	-	45	10	40	5
Gliricidia: Acacia (50:50)	22.5	22.5	10	40	5

Nutritive value of the block was tested with Red Madras crossbred male lambs. Feeding trial was conducted to evaluate metabolism crates. Experiment was arranged on a RCBD with three replicates. The treatments imposed were as follows.

T_1 - Basal ration Guinea grass (2% of the body weight on DM basis) supplemented with Gliricidia 100% block
T_2- Basal ration Guinea grass (2% of the body weight on DM basis) supplemented with Acacia 100% block
T_2- Basal ration Guinea grass (2% of the body weight on DM basis) supplemented with Gliricidia & Acacia (50: 50) block
T_4- Control; Guinea grass, 3% of the body weight on DM basis

Results showed that N intake was higher (Table 22) when block with Gliricidia was supplemented, in comparison to the control. At the same time N digestibility was shown to be lowered when block was supplemented, probably due to the high Tannin content in leguminous tree leaves. Although higher N intake is ensured with leguminous protein block, lower digestibility hinders the effective utilization, which has to be taken into account in further improvement of the block.

N retention as a percentage of absorbed N was significantly higher ($P<0.05$) in all treatments in comparison to control.

Table 22. *In-vivo digestibility and N balance of sheep under different treatments*

	Treatments			
	Gliricidia 100% (block)	Acacia 100%(block)	Gliricidia: Acacia (50:50) (block)	Guinea Grass
N intake (g/day)	14.45^{a}	11.38^{bc}	13.28^{ab}	9.43^{c}
N excretion (g/day)				
Faces	5.24^{ab}	4.85^{ab}	6.99^{a}	2.58^{b}
Urinary	2.02^{ab}	1.47^{b}	1.57^{b}	2.31^{a}
Total	7.26^{ab}	6.32^{ab}	8.56^{a}	4.89^{b}
N balance (g/day)	7.18^{a}	4.86^{ab}	4.71^{b}	4.50^{b}
In vivo digestibility	64.24^{a}	57.49^{bc}	47.64^{c}	74.46^{a}
N retention				
% of intake	50.10^{a}	44.54^{bc}	35.71^{a}	47.10^{a}
% of absorbed	77.97^{a}	77.53^{a}	75.65^{a}	65.55^{b}

Within row means followed by different letters are significantly different ($P<0.05$)

A D Samarajeewa, W D T D Gunaratna, M N M Ibrahim (Dept. of Animal Science, Faculty of Agriculture, University of Peradeniy)

PROJECT 23: ECONOMIC STUDIES ON FORMAL AND INFORMAL COCONUT PROCESSING INDUSTRY

Study 23.2: Consumer demand for Arrack: A preliminary analysis on the Coconut based Distillery industry

Coconut based arrack accounts 9% of the total arrack production in Sri Lanka. The tax on coconut-based arrack is comparatively higher than the other types of arrack and contributes 10% of the total arrack tax revenue. However, the amount of tax is the determining factor for the arrack price, which usually accounts 70% of the consumer price. Hence, any change in the tax structure can heavily influence on the consumer price inclined either to promote or depress the level of arrack consumption. The promotion of the arrack consumption has a direct impact on the toddy tapping industry, which is a sub coconut based industry. The aim of this study was to analyse the arrack consumers' responses for the economic variables.

The per capita consumption of arrack in 1989 was 1.8 litres, while in 1999 it was 2.75 litres showing an increase by two fold. However, the arrack price in real terms has been decreased by 13% for the same period, which may be a contributory factor for the increase in consumption levels. The results of the analysis revealed that the prices of arrack and, beer and consumer income were the significant variables, which determine the arrack consumption in Sri Lanka. The price elasticity of arrack demand was calculated as 1.6 and it is an elastic value. The value implies, for a one percent price reduction, the consumer increases the arrack consumption by 1.6 percent. The proportion of increase in arrack demand is higher than the price change. Therefore, a small reduction in the consumer price of arrack can enhance the demand by a noteworthy amount. Hence, there is a promising potential of

enhancing coconut based arrack consumption through a slight manipulation of the tax rate, which eventually create positive impacts on the coconut-based toddy tapping industry.

Beer acts as a weak substitute for arrack. The foreign liquor consumers tend to shift into arrack, when there is a price hike for those products. The income elasticity of arrack demand was calculated as 2.4. This indicates for one percent increase in the consumer income level, the arrack consumption increases by 2.4 percent. The changing life styles of people with the improvement in general living standards have created more demand for hard liquor such as arrack. Therefore, readily available quality arrack products with possible value additions can further increase the profit margins for the producers, who engage in the arrack industry, as the consumer undeniably accepts the product.

S R Samarajeewa and M T N Fernando

PROJECT 26: STUDIES ON IMPACTS OF FISCAL AND BUDGETARY POLICIES ON COCONUT INDUSTRY

Study 26.1: Analysis of the economic impact of price policies on the coconut sector of Sri Lanka

This study evaluates the impact of three major price policy instruments on the domestic coconut sector. There are three specific price policy instruments were, a) the coconut cultivation subsidy, b) import tariff on other edible oils, and c) export tax/cess on desiccated coconuts. A partial equilibrium framework for fresh coconut, desiccated coconut and coconut oil markets was developed, estimated and simulated to achieve the objectives of the study. The parameters for the behavioural equations were estimated using time series data for the period 1956-2000. The simulation of the coconut markets were done for the period from 1978 to 1999 to examine the economic impact of these three specific policy instruments on the domestic coconut sector. The policy shocks assumed an open market condition or with a situation that these policy instruments were not implemented in the domestic coconut sector.

The results of the econometric study revealed that the elasticity values obtained for the fresh coconut supply and demand were highly inelastic. A similar trend was found for the desiccated coconut and coconut oil markets as well. This implies that both producers and consumers are less responsive for the price changes in changing their production and consumption levels in the domestic coconut sector. The results of the simulation study suggest that the coconut cultivation subsidy has influenced not only the fresh coconut market, but also the coconut oil and desiccated coconut industries as well. The coconut cultivation subsidy has significant positive impact on the total national coconut production with a thirteen years lag on the investment. Also, the implementation of the coconut cultivation subsidy was helpful to reduce the retail price for coconuts in the domestic market and thereby to increase the quantity of coconut demand by the consumers. The removal of coconut cultivation subsidy would have adversely influenced on coconut oil and desiccated coconut markets by reducing the supply levels of these two markets as revealed by the results.

The protection of edible oil markets through a high tariff rate does not generate boost up supply shift in the domestic coconut oil industry as expected by the authorities, while the edible oil consumer is much affected by paying a higher retail price for coconut oil. The results of the simulation exercise suggest that the complete removal of tariff on domestic edible oil market would have only reduced the coconut oil supplies by about 8 percent, while the coconut oil consumer would have to pay 23 percent lower price for coconut oil at the domestic market. According to the results of this study, even with the complete opening up of the domestic edible oil market, the coconut oil suppliers would have to reduce their productions by a marginal amount. Therefore, opening up of the edible oil market is not the major cause for the malfunctioning of the domestic coconut oil industry, although it has substantial negative contributions.

The tax/cess on desiccated coconut exports does not generate significant negative impacts for desiccated coconut industry and for the other coconut industries as well. However, the desiccated coconut producer is the most affected group due to the implementation of this policy, while the world desiccated coconut consumers are also affected by paying higher export prices. According to the results of the simulation, all three coconut markets would not have adversely affected, neither considerably benefited due to the elimination of export tax on desiccated coconut. However, a zero tax policy on desiccated coconut exports largely benefits the desiccated coconut producer, who then can obtain a higher producer price.

S R Samarajeewa and
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Study 26.2: Macro economic policies and their implications on the domestic Coconut sector

The links between the macro economic policies and the domestic coconut sector were established to examine the direct impact of macro economic policies on the sector. The coconut export sector was specifically selected, hypothesizing that the export sector is more sensitive to the changes in the macro economy. The desiccated coconut, copra, coconut oil and coir fiber exports were considered in the analysis. The exchange rate and the inflation rate were selected as appropriate and included in the supply functions of major coconut export products together with other economic variables. The analysis included data for all the variables for the period 1970 –2000.

The results suggest that the coconut exports were not reactive to world price changes, while the domestic price of fresh coconuts or its availability is the key factor, which determines the quantity of coconut kernel product exports. The coconut kernel product exports have not significantly responded to the depreciated exchange rate, which has been implemented as an export promotion strategy by the governments. However, the coir fiber export sector gains the advantage of depreciated exchange rate to enhance the quantity of exports, as Sri Lanka operates as a price maker in the world Coir fiber market.

All coconut product exports are more sensitive to inflation and consequently to reduce the volume of exports. The anticipated favourable impacts of the macroeconomic policies, which encourage exports, have not been transmitted especially to the coconut kernel product exports sector, which earns more than 50 percent of the foreign exchange from total coconut product exports. The performance of this sector is largely depends on the availability of fresh coconuts in the domestic market. Hence, the coconut sector specific polices are more important, which attain this objective in the long run.

S R Samarajeewa and M T N Fernando

27: ECONOMIC STUDIES TO ENHANCE THE PRODCUTIVITY OF COCONUT LANDS

Study 27.1: Exploring the Potentials for Cultivation of Medicinal Plants under Coconuts

This study analyzes the profitability of growing medicinal plants under coconut and compares it with the profitability of alternative coconut-based land use systems, namely coconut-based mixed cropping and coconut-based energy plantations.

The results reveal that growing such medicinal plants as Thippili, Rathnitol and Katuwelbatu under coconuts is more profitable than other alternatives, i.e. coconut-based mixed cropping and energy plantations (Table 23).

Table 23. *Profitability of growing different crops under coconuts*

Cropping system	Gross margin (Rs/ha/year)
• C + Thippili	157 313
• C + Rathnitol	122 868
• C + Katuwelbatu	101 259
• C + betel + banana	89 337
• C + pineapple + banana	80 247
• C + gliricidia	77 875
• C + Kapukinissa	45 163
• Coconut monocrop	35 631

Note: C- coconuts.

This information may be useful to popularize growing of medicinal plants under coconuts.

H A D T Hettiarachchi, M T N Fernando and S C Rathnasiri

3. RESEARCH PROJECTS FUNDED BY OUTSIDE AGENCIES

3.1.1 Coconut based adaptive research programme (under the Second Perennial Crop Development Project funded by the Asian Development Bank).

At each site, the existing farmer practices are compared with recommended practices. The plots were generally above 0.5 ha.

The effect of factors such as planting materials, fertilizer, husk burial, mulching, irrigation and different types of perennial and seasonal intercrops (cocoa, coffee, pepper, rambutan, cashew, lime, mango, grafted durian, pineapple, passion fruit, banana, papaya and yam etc.) on are being compared. Agronomic and socio-economical data from each experiment site were collected in 2001.

Operations in 112 sites, out of the intended 125 sites have been commenced covering 15 administrative districts.

Results are summarized as follows.

a) Coconut

Newly released Tall x San Raman (TSR) variety was tested widely in different agro-ecological regions along with recommended improved variety, Tall x Tall (T x T). Initial growth of TSR was better than T x T in almost all the regions tested.

Nut yields of adult plantations have been improved with fertilization as recommended by the CRISL. In areas, where Mg deficiency was common (Galle, Kegalle), application of dolomite resulted in improvement in the leaf Mg levels of coconut and hence the effect is expected to be reflected in the yield too. Soil moisture conservation practices such as husk mulching and husk burial also resulted in increasing yields at on-farm level.

b) Intercrops

Among selected perennial intercrops, pepper was the most popular among growers in the wet and wet-intermediate zones. Several adaptive trials were established with cinnamon mainly in the Southern Province where it is a dominant crop. Spacing and different fertilizer types/levels are the research areas concerned. Cinnamon, which is a non-traditional crop, was established at several sites in Colombo, Kegalle and Kurunegala districts and the crop performance was satisfactory.

Grafted cashew was well established in all dry regions where farmers used to make low inputs or investments.

Growers in Matale and Kandy districts prefer intensive mixed cropping models, which include more number of perennial intercrops such as clove, durian and rambutan.

In Galle and Matara districts where tea/coconut mixed cropping is dominant and pepper was found to be ideal to diversify the existing system. Rambutan has shown good performance in Galle, Matara, Rathnapura and Kegalle districts.

Several growers in Kurunegala district prefer cocoa as an intercrop and the growth was fairly good. However, the real economic benefits would depend on the fluctuating in market price.

Grafted avocado was also established in several sites in Gampaha and Moneragala districts and its growth performance was satisfactory.

Pineapple showed outstanding growth and yield performance in Galle and Matara districts. Cost of production of pineapple was nearly 1/3 less in those districts compared to traditional areas in Gampaha and Kurunegala districts. This was mainly due to low cost in weed control and land preparation and favourable rainfall conditions in Galle and Matara.

Passion fruit produced over 10 kg/vine during the first year of establishment in Rathnapura and Galle districts. This is a very good yield when compared to that of traditional areas (Kalutara and Gampaha districts).

Growers in the dry zone preferred to cultivate vegetables during the initial stage of perennial intercrops such as mango, cashew and lime.

Drought was one of the major constraints to the success of this coconut-based perennial intercropping systems.

The project is in progress.

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And P A P Udayakumara

3.1.2 IPGRI/DFID-funded Socio-economic Survey (LOA: AP/020)

The purpose of this survey was to select project sites for a nationwide deployment of coconut-based poverty reduction interventions in coconut-growing communities using COGENT's 3-pronged strategy in Sri Lanka.

Coconut holdings less than 1.5 ha constitute some 82 per cent of smallholdings[1]. These coconut farmers earn marginal income, quite often living below the poverty level. It is hypothesized that their income can be increased by using COGENT's three-pronged strategy, viz:,

i) Increase coconut yields by deploying high yielding coconut varieties, thereby increasing farmers' income,

[1] Coconut smallholders are defined as farmers having less than 8 ha.

ii) Promotion of production and marketing of high value products from the meat, husk, shell, water, wood and leaves thereby increasing farmers' income, and

iii) Increase farmers' incomes through intercropping and livestock/fodder production.

Four communities, namely a treacle-producing community, a livestock farming community, a white coir fibre-producing community and an ekel handicrafts-producing community were identified for the study. A survey was conducted from March to May 2001 to identify: a) their baseline economic situation, and b) The suitable one out of COGENT's three approaches that can be made used to uplift their economic and social situation.

The identified approaches are to be implemented to each community to test the hypothesis that their income can be improved by adopting COGENT's three approaches.

The results of these experimental sites will enable to extend the adoption of the 3 approaches to similar communities in other geographical focuses.

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S D J N Subasinghe and K V N N Jayalath

3.3 USAID-funded Project on Local Coir Industry Analysis

A survey on the coir industry was conducted from September to October 2001 by inteviewing 21 coir milers and 10 coir exporters to identify and analyze the factors inhibiting the ability of coir system to deliver coir that meet the needs of the local market.

The non-existence of a grading system of coir results in lack of transparency between millers and exporters in pricing of coir. Identification of coir attributes and their standards are a prerequisite to develop a grading system of coir. Once a grading system is devised, a corresponding quality-based pricing system can be developed, which provides an incentive to millers for producing fibre of improved quality.

Turbo cleaners have to be installed to get high quality fibre. This, in addition to the fixed overheads, involves additional: a) labour, b) energy (electricity/diesel), and c) loosing of fibre weight. The pricing system therefore has to be formulated taking these aspects into account. Even if the grades are published, if their measurement is clumsy, purchasing officers of exporters' factories naturally tend to revert to their former practice of visual judgment. So, there is a need for development of user-friendly measurement methodologies. Whatever the appealing measurement methodologies are developed, good governance of exporters' purchasing staff is essential so that they would not involve in any malpractices with coir suppliers such as measuring the quality parameters of purposely selected coir samples instead of random samples.

4. MISCELLANEOUS STUDIES

4.1 Demonstration Farm, Tabbowa, Nattandiya.

Total extent of 2.5 ha of farm is being managed on a self-financing basis to demonstrate improved cultural practices in coconut cultivation. During the year, 11,029 coconut seedlings were issued and total income was Rs. 460,694.46. The net profit of the farm was Rs.19,515.82.

Table 24. *Income and expenditure, Demonstration Farm, Tabbowa*

Income			Expenditure	
Item	Quantity (Nuts/ Seedling)	Value (Rs.)	Item	Value (Rs.)
a) Sale of coconut	22299	132,712.21	a) Labour	246,637.42
b) Sale of coconut Seedlings			b) Other materials	62,912.00
Poly Baged -			c) Electricity	8,480.00
TxT	1269	53,298.00	d) Seednuts	123,149.22
DxT	326	13,692.00		
RD	40	1,680.00		
Bare rooted -				
TxT	9211	239,486.00		
DxT	183	4,575.00		
c) Sale of other crops		15,251.25		
Total Income		460,694.46	Total expenditure	441,178.64

Profit: 19,515.82

Several groups from various agricultural training schools and coconut growers visited the farm.

H A J Gunathilake and R A Swarnathilake

4.2 Animal Breeding Programs

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

During the year, 40 goats were sold among the farmers identified by the local veterinary officer.

Table 25. *Details of animal herd*

Animal	Place	Breed	Herd End of 2000		Herd End of 2001		Sold in 2001	
			F	M	F	M	F	M
Buffalo	Makandura	Moora	12	9	16	6	-	4
	Ambakelle	Moora	18	8	19	14	-	-
Goat	PRS	Sri Lankan Boer'	40	44	15	68	6	14

ACKNOWLEDGEMENTS

The cooperation and assistance of the staff of the Agronomy Division in conducting the experiments, demonstrations and training programmes during the year are gratefully acknowledged.

My thanks are due to Mr. D T Mathes, Head/Biometry and the staff of the Biometry Division for continuos assistance with designing of experiments and analysis of data, and Dr. L L W Somasiri, Head and Staff of the Soils and Plant Nutrition Division for chemical analysis of plant and soil samples.

REPORT OF THE GENETICS AND PLANT BREEDING DIVISION
Acting Head - J.M.D.T. Everard M.Sc.

1. General

The multi-locational evaluation of improved coconut cultivators, now in the 18th year, aptly demonstrated the superiority of inter-varietal hybrids, *dwarf green x tall* and *dwarf yellow x tall* (CRIC65) over pure tall cultivators, *tall x tall* (CRIC60), *Moorock tall* and *plus palm tall* selections at all the four locations, Bandirippuwa (Lunuwila), Thammenna (Puttalam), Suriyapura (Gampaha) and Palugaswewa (Chilaw). Over the years, nut and copra yields of *dwarf x tall* hybrids were significantly better than pure tall cultivators at all the sites. In 2001, even the tall improved cultivator; CRIC60 became prominent at the better-managed Bandirippuwa site. *Dwarf green x tall* was the best, averaging 16,900 nuts/ha while *dwarf yellow x tall* ranked 2nd, averaging 14,600 nuts/ha. The intra-varietal hybrid *tall x tall* (CRIC60) ranked 3rd with a significantly better yield of 12,500 nuts/ha over *plus palm tall* (11,000 nuts/ha) and *Moorock tall* (10,000 nuts/ha) at Bandirippuwa.

The assessment of the performance of F_1 progeny from crosses between selected *tall* palms at ISG, *dwarf green* and *san ramon* also generated very useful information from two sites, Bandirippuwa and Ratmalagara. Progenies of *tall x dwarf green* gave highest nut yields while *tall x san ramon* produced excessively large fruits carrying nearly 300 g of copra/nut. The production and distribution of *tall x san ramon* (CRISL98), the new release, for adaptive trials was continued and around 3800 seedlings were distributed among enthusiastic growers island wide. Establishment of the Pallama Seed Garden (PSG) for mass production of CRISL98 (*tall x san ramon*) was continued at a rapid pace with nearly 75 ac (5000 seedlings) being established with *tall* and *san ramon*.

Collection and conservation of coconut germplasm continued in the usual manner. Three more accessions, Aparakka, Digdenipotha and Bathigama from the Matara district were added to the collection. The field gene banks were maintained with routine operations and growth measurements were recorded of 13 accessions established at the Pallama Seed Garden. Kohombana Gene Bank located at Coconut Cultivation Board (CCB) premises, Gonagolla, Amparai was noteworthy because the site predominantly have collections from the Amparai neighborhood. CCB was requested to expand this gene bank further by rejuvenating the three Amparai accessions, Damana, Deegawapi and Kohombana. The Coconut Genetic Resources Database (CGRD) of the COGENT was updated with the passport and characterization information gathered from field gene banks.

DNA assaying was intensified by using three types of DNA markers, RAPD, SSRP and AFLP to detect polymorhisms in coconut to study the genetic relationships of conserved coconut germplasm in the country. The results obtained with these markers revealed that the Sri Lankan germplasm fall into two groups, one representing the genome of African tall coconuts and the other Pacific coconuts. All tall coconuts except the Philippine type, San Ramon and its derivatives fell into the former group while dwarf coconuts fell into the group constituting the Philippine types. Dwarf coconuts probably retained the original coconut genome due in part to

its predominantly inbreeding reproductive behavior. Three germplasm accessions collected from ancient villages in Amparai shared a unique genome probably indicating a common source of origin somewhat different from domesticated coconuts in other parts of the country. The overall results on genetic distances however, suggested the strong need for germplasm enrichment by introduction of exotic coconuts if at all a quantum increase in coconut productivity is expected by hybrid development. Arrangements are being made through COGENT for importation of 23 germplasm accessions, nine from India, six from Ivory Coast and eight from Fiji and PNG. Financial assistance from CESS is expected for the importation and establishment of exotic germplasm.

PROGRESS OF RESEARCH

Project: EVALUATION OF EXISTING CULTIVARS (1983/86)
Experiment 12.1.1 Evaluation of five improved cultivars; *dwarf green x tall (CRIC65), dwarf yellow x tall (CRIC65), tall x tall (CRIC60), Moorock tall (MT) and plus palm tall (PPT)*

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

Locations and agro-climatic conditions

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

The experiment at the two sites, Bandirippuwa and Thammenna are comparable as they both commenced at the same year. The rainfall intensity and distribution at these sites since 1993 are given below (Table 1).

Table 1. *Rainfall intensity (annual rainfall in mm) and distribution (number of wet days/year) at Thammenna and Bandirippuwa during 1993-2001*

Year	Bandirippuwa		Thammenna	
	Rainfall intensity	Rainfall distrib^{n}	Rainfall intensity	Rainfall distrib^{n}
1993	1779	156	872	44
1994	1905	140	875	40
1995	1944	135	1163	44
1996	1739	128	823	42
1997	1902	140	916	62
1998	1998	130	1009	34
1999	2215	126	1086	48
2000	1687	110	976	34
Total	15169	1065	7720	348
Mean	1685	118	857	70
2001	1055	87	756	35

The two sites differed markedly in intensity and distribution of rainfall from 1993 - 2000 with former averaging 1685 mm and 118 wet days annually while latter 857 mm and 70 wet days annually. The deep well drained latasol soil at Thammenna, which is more conducive for coconut growth than the loamy sand soil at Bandirippuwa, however, was expected to compensate the relatively poor rainfall at the site in the performance of cultivators. The better overall yields of all the cultivators at Bandrirppuwa in the last eight years however, indicated water as the main contributory factor in high performance of improved cultivators (Table 2). The Bandirippuwa site favored all the cultivators in a more consistent fashion than

Thammenna, where yields fluctuated drastically from year to year with no consistent pattern. The yield trends of all cultivators at Bandirippuwa (Figure 1) fitted well to a characteristic power model of yield increase common to plantations reaching yield stability. Thammenna yields did not follow any expected pattern linear, exponential, logarithmic, power or polynomial during the period of observation i.e., 9-17 years since planting.

Table 2. *Nuts /palm/year of dwarf green x tall (CRIC65), dwarf yellow x tall (CRIC65), tall x tall (CRIC60), Moorck tall (MT) and plus palm tall (PPT) in the multi-locational evaluation of improved cultivators at the two sites, Bandirippuwa (BE) and Thammenna (TE) from 1994 - 2001.*

		Nut yield (nuts/palm/year)								*Eight-year average*	
		1994	1995	1996	1997	1998	1999	2000	2001	Nuts/ palm	Nuts/ha
Site	Years after Planting	10	11	12	13	14	15	16	17		
BE	DGxT	101	70	67	46	47	103	78	89[a]	74[a]	14,800
	DYxT	83	61	65	45	57	88	71	76[a]	69[a]	13,800
	TxT	51	47	48	32	32	63	64	64[bc]	50[b]	10,000
	MT	39	45	42	32	30	51	55	52[c]	44[b]	8,800
	PPT	50	50	44	34	34	56	60	59[c]	48[b]	9,600
TE	DGxT	60	80	73	81	32	107	30	89[a]	69[a]	13,800
	DYxT	39	63	65	71	32	81	35	72[a]	57[a]	11,400
	TxT	28	46	51	46	20	45	26	49[b]	38[b]	7,600
	MT	24	35	36	36	17	39	25	41[b]	32[b]	6,400
	PPT	31	47	49	49	22	46	30	49[b]	41[b]	8,200

[a b] and [c] significantly different groups

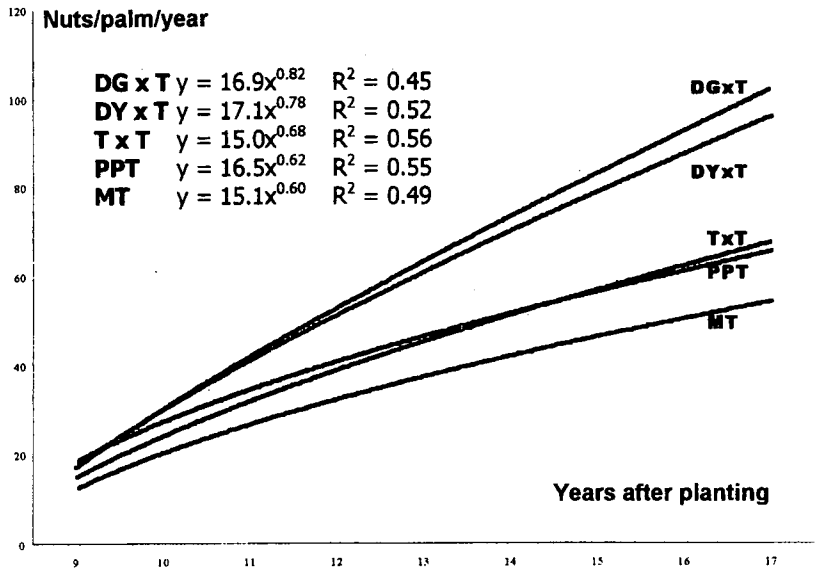

Figure 1. *Trends in nut production of different cultivators at Bandirippuwa from 9-17 years of planting (1994-2001)*

`The overall performance of the five cultivators since 1994 to date (10 - 18 years since planting), clearly exemplified the superiority of inter-varietal hybrids, *dwarf green x tall* and *dwarf yellow x tall* over intra-varietal hybrids, *tall x tall*, *Moorock tall* and *plus palm tall* at both sites. *Dwarf green x tall* was the best in both sites with an average production of approximately 14,300 nuts/ha. *Dwarf yellow x tall* ranked second with an average of 12,600 nuts/ha. The performance of *tall* cultivators did not differ statistically within themselves but ranks of *tall x tall* (CRIC60) and *plus palm tall* changing in the order at Bandirippuwa and Thammenna. The improved cultivator, *tall x tall* being selected from very high yielding estates in the intermediate zone, which were more conducive for coconut and bred within themselves, responded well for conditions at Bandirippuwa. In contrast, at Thammenna where the rainfall was poor and notably the standard of management was below the mark, *tall x tall* suffered excessively than the *plus palm tall. Plus palm tall* is a mixture of coconut collected from selected high yielding palms scattered over the coconut growing regions in the country and as result was more genetically diverse than *tall x tall,* which constitute a very narrow genetic base. *Moorock tall* has much narrower genetic base being an inbred selection from an estate in Mawathagama where the annual rainfall was above 2000 mm, ranked lowest at both sites throughout the period.

The scenario in the year 2001 was more in favor of improved cultivators including *tall x tall* (CRIC60). The five cultivators ranked in the same order at the two sites, Bandirippuwa and Thammenna. *Dwarf green x tall* ranked first performing equally well at both sites yielding 89 nuts/palm/year (app. 16,900 nuts/ha) at both sites. *Dwarf yellow x tall* ranked 2nd with yields of 76 nuts/palm/year (app. 14,600 nuts/ha) and 72 nuts/palm/year (app. 13,000 nuts/ha) at the two sites Bandirippuwa and Thammenna respectively. The intra-varietal hybrid *tall x tall* ranked 3rd with respective yields of 64 nuts/palm/year (app. 12,500 nuts/ha) and 49 nuts/palm/year (app. 9,300 nuts/ha). *Plus palm tall* (59 nuts/palm/year or 11,000 nuts/ha at Bandirippuwa and 49 nuts/palm/year or 8,700 nuts/ha at Thammenna) and *Moorock tall* (52 nuts/palm/year or 10,000 nuts/ha at Bandirippuwa and 41 nuts/palm/year or 7,600 nuts/ha at Thammenna) ranked 4th and 5th respectively.

The yield data of the five cultivators at the other two comparable sites, Suriyapura and Palugaswewa are given in Table 3. Here again the six-year averages at both sites clearly indicate the better performance of inter-varietal hybrids, *dwarf green x tall* and *dwarf yellow x tall*. The other interesting feature is the relatively better performance of Moorock tall among the three tall cultivators at Suriypura, the site, which experiences the highest rainfall. This probably was attributed to earlier mention fact that this cultivator is an inbred population from a wet zone estate.

The coconut yields in 2001 are slightly better in Suriyapura comparing to that of previous year and *vice versa* occurred in Palugaswewa. *Dwarf green x tall* ranked 1st performing equally well at both sites yielding 64 nuts/palm/year (app. 12,800 nuts/ha) at Suriyapura and 61 nuts/palm/year (app. 12,200 nuts/ha) at Palugaswewa. *Dwarf yellow x tall* ranked 2nd with yields of 55 nuts/palm/year (app. 11,000 nuts/ha) and 59 nuts/palm/year (app. 11,800 nuts/ha) at the respective sites. The intra-varietal hybrid *Moorock tall* ranked 3rd at Suriyapura with an yield of 50 nuts/palm/year (app. 10,000 nuts/ha) and ranked 4th at Palugaswewa with an yield of 41 nuts/palm/year (app. 8,200 nuts/ha). *Tall x tall* (42 nuts/palm/year or 8,400 nuts/ha) was slightly better than *Plus palm tall* (40 nuts/palm/year or 8,000 nuts/ha at Suriyapura while the situation is reversed at Palugaswewa where *plus palm tall* (46 nuts/palm/year or 9,200 nuts/ha) is significantly better than *tall x tall* (38 nuts/palm/year or 7,600 nuts/ha).

The fruit components were analyzed in the three sites, Bandirippuwa, Thammenna, and Suriyapura resolving a nut each of every palm in all the six picks into husk, shell and kernel. Table 4 summarizes the data obtained from the three sites. In general nuts of *Moorock tall* are bigger averaging 1530 g comparing to *tall x tall* and *plus palm tall* both of which had nuts weighing about the same (1500 g). The nuts of inter-varietal hybrids, *dwarf yellow x tall* (1385 g) and *dwarf green x tall* (1260 g) were significantly smaller in size comparing to that of pure tall cultivators. Other fruit components, husked nut weight, split nut weight and kernel weight too followed the same pattern with *tall x tall* having slightly better weights than *plus palm tall*. The results at Suriyapura, however is not very consistent and collection of more data is necessary to arrive at decisions that are more conclusive.

Table 3. *Nuts /palm/year of dwarf green x tall (CRIC65), dwarf yellow x tall (CRIC65), tall x tall (CRIC60), Moorck tall (MT) and plus palm tall (PPT) in the multi-locational evaluation of improved cultivators at the two sites, Suriyapura (SE) and Palugaswewa (PE) from 1994 - 2001*

		Nut yield (nuts/palm/year						*Six-year average*	
Site		1996	1997	1998	1999	2000	2001	Nuts/palm	Nuts/ha
	Years after planting	10	11	12	13	14	15		
SE	DGxT	26	25	36	61	61	64[a]	46[a]	9,200
	DyxT	17	22	35	51	52	55[b]	39[b]	7,800
	TxT	10	16	27	29	36	42[c]	27[c]	5,400
	MT	11	10	30	37	41	50[b]	30[c]	6,000
	PPT	12	17	20	29	38	40[c]	26[c]	5,200
PE	DGxT	45	63	34	52	55	61[a]	52[a]	10,400
	DyxT	34	61	36	51	63	59[a]	51[a]	10,200
	TxT	32	63	20	42	46	38[c]	40[b]	8,000
	MT	18	59	18	41	44	41[c]	37[b]	7,400
	PPT	24	53	17	46	50	46[b]	40[b]	8,000

[a] [b] and [c] significantly different groups

Copra production by each cultivator at the two sites, Bandirippuwa and Thammenna were examined over the 8-year period from 1993 - 2001 (Table 5). The copra/nut has been consistent throughout the period with *Moorck tall* averaging the highest copra outturn per nut (269 g/nut) at the Bandirippuwa site. All the cultivators recorded better per nut copra yields at Bandirippuwa comparing to Thammenna and at both sites, pure tall cultivators recorded better weights. At the Bandirppuwa site, both *Moorock tall* and *tall x tall* recorded significantly better weights of copra per nut than *plus palm tall*.

Table 4. *Fruit components of the five cultivators, dwarf green x tall (CRIC65), dwarf yellow x tall (CRIC65), tall x tall (CRIC60), Moorock tall (MT) and plus palm tall (PPT) in the multi-locational evaluation of improved culitvars at three sites, Bandirppuwa (BE), Thammenna (TE) and Suriyapura (SE) and Palugaswewa (PE) in the 2001.*

Site and cultivar	Mean fresh Nut weight (g)	Mean husked Nut weight (g)	Mean split nut weight (g)	Mean kernel Nut weight (g)	Mean weight of Copra (g / nut)
BE					
DG x T	1110 [a] ± 27	649 ± 15	501 ± 09	337 ± 07	208 ± 05
DY x T	1273 [b] ± 27	703 ±16	520 ± 10	343 ± 07	225 ± 05
T x T	1380 [c] ± 30	782 ± 18	602 ± 11	385 ± 08	250 ± 06
MT	1518 [d] ± 31	872 ± 19	658 ± 11	427 ± 08	279 ± 06
PPT	1369 [c] ± 35	745 ± 75	577 ± 10	370 ± 08	238 ± 05
TE					
DG x T	1255 [a] ± 27	558 ± 13	429 ± 09	289 ± 07	179 ± 05
DY x T	1347 [b] ± 27	625 ± 16	455 ± 10	300 ± 08	200 ± 05
T x T	1600 [cd] ± 28	710 ± 16	535 ± 11	342 ± 09	227 ± 06
MT	1560 [c] ± 29	657± 14	499 ± 09	324 ±08	210 ± 06
PPT	1581 [cd] ± 26	692± 15	521 ± 09	334 ± 09	221 ±05
SE					
DG x T	1423 [a] ± 32	831 ± 20	610 ±13	416 ±09	266 ± 06
DY x T	1535 [c] ± 43	938 ± 26	637 ± 12	430 ± 11	300 ± 08
T x T	1516 [b] ± 34	872 ± 18	647 ± 12	433 ± 08	279 ± 06
MT	1506 [b] ± 35	1040 ± 45	661 ± 12	529 ±15	333 ±14
PPT	1548 [c] ± 26	865 ± 18	640 ± 12	495 ±15	277 ± 06
Average					
DG x T	1263 [a]	679	513	347	218
DY x T	1385 [b]	755	537	358	242
T x T	1499 [c]	788	595	387	252
MT	1528 [d]	856	606	427	274
PPT	1499 [c]	767	579	400	245

[a b,c] and [d] significantly different groups

The overall outturn of copra by each cultivator was also assessed and the results are given Table 6. Although the copra outturns per nut by inter-varietal hybrids, *dwarf green x tall* and *dwarf yellow x tall* were less than that by *tall* cultivators, *tall x tall, Moorock tall* and *plus palm tall* the overall copra outturn per unit land (kg/ha) by inter-varietal hybrids was still high. *Dwarf green x tall,* again being the best followed by *dwarf yellow x tall.* It is encouraging to note that the copra outturn of CRIC60 is better than other *tall* selections, *Moorock* and *plus palm* at Bandirippuwa and Thammenna.

Table 5. *Copra (g)/nut in the five cultivators, dwarf green x tall (CRIC65), dwarf yellow x tall (CRIC65), tall x tall (CRIC60), Moorock tall (MT) and plus palm tall (PPT) in the multi-locational evaluation of improved cultivators at the two sites, Bandirippuwa (BE) and Thammenna (TE) from 1994 - 2001*

Site	Year	1994	1995	1996	1997	1998	1999	2000	2001	Average
	Years After planting	10	11	12	13	14	15	16	17	
	Culitvar									
BE	DgxT	219	231	194	209	224	229	240	208[a]	219
	DyxT	230	246	203	227	224	237	250	225[b]	230
	TxT	257	244	226	246	265	284	284	250[c]	257
	MT	269	255	245	253	272	284	294	279[d]	269
	PPT	240	235	219	237	250	257	244	238[bc]	240
TE	DGxT	202	216	209	212	188	221	189	179[a]	202
	DyxT	206	217	209	194	188	230	201	200[b]	206
	TxT	227	229	230	235	195	256	214	227[c]	227
	MT	221	226	229	229	195	246	215	210[bc]	221
	PPT	224	233	228	229	199	251	207	221[c]	224

[a b,c] and [d] significantly different groups

Table 6. *The overall production of copra (kg)/ by the five cultivators, dwarf green x tall (DGxT, CRIC65), dwarf yellow x tall (DYxT, CRIC65), tall x tall (TxT, CRIC60), Moorock tall (MT) and plus palm tall (PPT) in the multi-locational evaluation of improved cultivators at the two sites, Bandirippuwa (BE) and Thammenna (TE) in 2001*

Site	Bandirippuwa		Thammenna		Suriyapura	
Cultivar	Kg/ palm	Kg/ha	Kg/ Palm	Kg/ha	Kg/ palm	Kg/ha
DGxT	19	3517	16	3027	17	2964
DyxT	17	3292	14	2592	17	2930
TxT	16	3120	11	2113	12	2008
MT	15	2793	9	1593	17	2802
PPT	14	2668	11	1922	11	1821

The overall results from the onset of this experiment to date clearly demonstrated the superiority of intra-varietal hybrids *dwarf green x tall* and *dwarf yellow x tall* over pure tall cultivators, *tall x tall*, *Moorock tall* and *plus palm tall* in all important agronomic aspects such as time for germination, early growth as revealed by the annual rates of girth, height and leaf increase, precocity, nut and copra yield per unit land. The striking feature is the ability of *dwarf x tall* hybrids to maintain its superiority over others even under poor management. Among the four sites discussed, all except Bandirippuwa were inadequately managed. Weeding, removals of old stand, pest control, moisture conservation practices were hardly attended and even fertilizer application was unattended in certain years.

Management of Thammenna and Palugaswewa has been extremely poor after being leased to Chilaw Plantation Company Ltd. in early 1990's. Suriyapura now being an isolated fragmented land owned by a real estate broker is in the verge of blocking out for domestic constructions. It should be noted that all these three sites and Dambakande, where the same experiment was simultaneously established but terminated after three years as land was occupied by the Army, were property of the JEDB at the inception of the experiment. In view of this unfortunate circumstance the purpose of this experiment, multi-locational testing of improved cultivators was lost, as the results are not comparative across sites due to non-uniform management and other reasons beyond the control of the CRI.

Conclusively the results obtained at Bandirppuwa can be considered as a clear description of the relative performance of the five improved cultivators in a sandy loam soil (S_2) under rain fed conditions with basic management practices recommended by the CRI. In summary all the cultivators have reached yield stability at Bandirippuwa after 17 years from planting with CRIC65 (*dwarf x tall*) hybrids and CRIC60 (*tall x tall*) respectively attaining production levels of 3,400 kg of copra/ha (16,500 nuts/ha) and 3,100 kg of copra/ha (13,000 nuts/ha). *Moorock tall* and *Plus palm tall* being less superior attained a production level of 2,800 kg of copra/ha (10,000 nuts/ha) and 2,700 kg of copra/ha (12,000 nuts/ha).

J.M.D.T. Everard, S.A.C.N. Perera, W B S Fernando, M H L Padmasiri, R.B. Attanayake and S. Mallawaarachchi

Project: ON-FARM EVALUATION OF NEW CULTIVARS
Experiment 12.1.2 Evaluation of CRISL98 (*tall x san ramon*) under farmer conditions

In order to assess the performance of the CRI's new release CRISL98 *(tall x san ramon*) 51 tall palms at ISG were selected and hand pollinated continuously with pollen collected and processed from *san ramon* palms at Bandirippuwa. The seeds were raised at ISG and issued to enthusiastic growers who wish to replant 1-2-acre blocks. In addition, these seedlings were also issued to adaptive trials of the Agronomy Division to assess their performance in a range of agro-climatic environments under various farming systems. For all these studies, the seedlings were sold at the rate of Rs. 60.00 per seedling.

In the year 2001, 3797 seedlings were distributed predominantly among growers in Kurunegala (1228), Puttalam (1435), Gampaha (402), Galle (310) Kegalle (151), Polonnaruwa (62) and Matale (60) Districts. These sites would be monitored with minimum intervention by the division.

It is also expected to establish CRISL98 plot at CRI estates, Bandirippuwa and Duncannawa in near future.

J.M.D.T. Everard, S.A.C.N. Perera and S. Mallawarachchi

Experiment 12.1.3 Evaluation of Ambakelle special under farmer conditions

Similar to above experiment Ambakelle special is also expected to evaluate under farmer conditions as in the same manner described in above (Experiment 12.1.2). Seeds are now being raised at the Bandirppuwa estate nursery for this purpose.

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

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

The cross *dwarf green x san ramon,* which is now under evaluation at the Daisy Valley estate Mawathagama (described under progeny testing in a preceding section) is appearing to be promising and likely to be the next release of the CRI. This cross however, is evaluated only in the above site and therefore, need testing in a wide range of environments as its response to varying agro-climatic conditions especially under farmer management. Therefore, 100 *dwarf green* palms at ISG would be dedicated from 2002 for production of *dwarf green x san ramon* by hand pollination. The *dwarf green x san ramon* seedlings too will be evaluated as in the same manner described in above (Experiment 12.1.2).

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

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. Program 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 No. 14/ at 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. These two experimental blocks are progressing well with 93% flowering at the ISG and 88% at MOSG.

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

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 : ISG **Agro-climatic zone/soil type :** Dry intermediate zone

This assessment of full sib families was established to evaluate the performance of the progeny of palms selected from fields 1 and 2 of the ISG based on consistency in giving high yields for over 18 consecutive years. This experiment however, suffered a severe set back at early stages of development due to high casualties of water logging. The nut productions as family means along with last 6-year averages are given in Table 7.

Table 7. *Nut yields (nuts/palm/year) of the half sib families planted in field 11A/ISG arising from parents selected from Field 1 and 2 at ISG.*

Mother palm	Family mean	Six-year average	Mother palm	Family mean	Six-year average
1.02	79	68	1.21	67	56
1.04	67	56	1.28	87	71
1.05	70	54	1.31	85	65
1.06	73	57	1.34	63	47
1.07	68	55	2.01	66	46
1.09	87	73	2.37	69	53
1.10	76	61	2.44	73	63
1.11	55	38	2.53	57	44
1.12	77	63	2.57	69	58

The yield in general has increased in all the families with six-year average surpassing 60 nuts/palm/year in seven families. Among these, the families 1.02, 1.09, 1.28 and 2.44 have consistently yielded above 50 nuts/palm/year.

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)

Progeny arising from four crosses between *Ambakelle tall* and four germplasm accessions, *Moorock tall*, *St Anne's tall*, *Kasagala tall* and *Debarayaya tall* are being evaluated along with *Ambakelle special* at five different locations to test hybrid vigor with special reference to yield stability and drought tolerance.

The measurement of growth was completed in the experiments at Siringapatha, Melsiripura and Girtland Estates, which completed five years after establishment while leaf production was measured at the two remaining sites, Batatta and Kivulakelle. The average leaf production during the year is given in Table 8.

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 intermed.
11.2a	Melsiripura	1995	Reddish brown latasol	Wet intermed.
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

Table 8. *Mean number of new leaves produced by progeny of the 5 crosses planted at Batatta and Kivulakelle (LSD = Least significant difference at 0.05 level).*

Cross	Batatta			Kivulakelle		
	'99	'00	'01	'99	'00	'01
Tall x Moorock	5.2	5.73 [bc]	7.2	4.7	5.38	6.2
Tall x St. Anne's	5.3	6.19 [bc]	6.3	4.7	4.93	6.3
Tall x Debarayaya	5.4	6.60 [ab]	6.8	4.6	5.35	6.5
Tall x Kasagala	5.1	5.66 [c]	6.9	4.3	5.15	6.5
Ambakelle Special	5.9	7.16[a]	7.1	4.7	5.16	6.7

[a,b] and [c] significantly different groups

The rate of leaf production shows a slight but steady increase in all the crosses at both sites. The overall growth rate at both sites comparing to other sites at the corresponding age however, was poor. These two sites have suffered immensely from drought and poor management. The Batatta site was completely neglected during the severe drought at Hambantota and wilting caused 43 deaths.

Flowering has initiated in the three sites, Siringapatha, Melsiripura, and Girtland and the percentages of flowering in each category are given in Table 9.

Table 9. *Percentage flowering in progeny of the five crosses planted at Siringapatha, Melsiripura and Girtland Estates during 1996-1997.*

Cross	Siringapatha		Melsiripura		Girtland	
	2000	2001	2000	2001	2000	2001
Palms in flower	5	22	7	33	8	41
Cumulative percentage	1	4	1	6	2	10

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

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. The status of flowering as at 31st December 2001 is summarized in Table 10.

Table 10. *The status of flowering in the evaluation of dwarf green x debarayaya tall at Raddegoda*

Cross	Number and percentage of palms in flower		
Year	1999	2000	2001*
Years after planting	4	5	6
Debarayaya tall x dwarf green	32 (67%)	40 (83%)	46 (100%)
Ambakelle tall x dwarf green	31 (64%)	44 (92%)	47 (100%)

* All flowered except for vacancies

S A C N Perera, 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 years from planting are summarized in Table 11. 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 11. *Total number of leaves, rate of leaf production/6 months, girth and height of seedlings planted at Loling Estate Payagala after 36 months after planting. (D, Dwarf; T, Tall; CRD, Cameroon Red Dwarf).*

Cross	Number of seedlings Measured	Total number of leaves	Annual rate of leaf production
Dwarf green x Ambakelle tall	156	11	9.1
Cameroon red dwarf x Ambakelle tall	111	10	10.9
Dwarf green x Debarayaya tall	109	11	8.8
Ambakelle special	49	9	9.4

S A C N Perera, J.M.D.T. Everard and N Herath

Experiment 12.4 Selfing of F_2 palms at Bandirippuwa Estate and evaluation of F_3 progenies at Ratmalagara (1994)

This experiment was established for comparing self and open pollinated progenies arose from *dwarf x tall* hybrids in order to assess the segregation of desirable traits in subsequent generations. Thirty-six F_3 families arose from selfed and open pollinated 18 F_2 palms were planted in a fully randomized fashion at the Ratmalagara Estate in November 1995. The leaf production was measured up to 54

months and is expected to analyses after obtaining the final measurement at 60 months.

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

Project: **EVALUATION OF PROGENIES OF SELECTED PALMS AT AMBAKELLE**

Experiment: **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 and 10 palms/plot.

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)

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

Differential fertilizer application was commenced at Ratmalagara and Bandirippuwa after 75% of the palms attained flowering (since 1993). The rest of the sites were used purely for testing progenies under different agro-climatic areas with average management. The nut yield during 1998-2000 at the two sites are given in Table 12

Table 12. *Nut yield (nuts/palm/yr.) of the progenies, tall x dwarf green, tall x tall and tall x san ramon and three fertilizer levels at Bandirippuwa and Ratmalagara during 1998-2001.*

Treatment	Bandirippuwa[1]				Ratmalagara			
	1998	19991	2000	2001	1998	1999	2000	2001
Year after planting	13	14	15	16	13	14	15	16
Variety								
T x DG	41[a]	97[a]	74[a]	78[a]	50[a]	110[a]	89[a]	100[a]
T x T	40[a]	54[b]	61[b]	51[b]	30[b]	60[b]	66[b]	72[b]
T x SR	34[a]	40[b]	54[b]	48[b]	33[b]	57[b]	68[b]	68[b]
Fertilizer level								
T1 recommended	41[a]	62[a]	67[a]	60[a]	35[a]	76[a]	69[b]	79[a]
T2 half	35[a]	57[a]	58[b]	56[a]	35[a]	78[a]	75[ab]	79[a]
T3 one and a half	39[a]	63[a]	64[a]	60[a]	39[a]	74[a]	78[a]	82[a]

[1] 10% of palms subjected for controlled pollination, [a] and [b] within year values with the same letter are not significant at P>0.05.

The *tall x dwarf green* progeny once again maintained a significant superiority in the production of nuts at both sites reaching the mark 100 nuts/palm/year at Ratmalagara. The yields of *tall x tall* and *tall x san ramon* too are quite substantial at Ratmalagara. The limited success in Bandirippuwa is probably due to the particular site, which has a very poor soil falling in the S4 category.

Response to differential application of fertilizer was still not evident at both sites. Variety x level of fertilizer interaction was also not evident at both sites (Table 13). However, the current yields of all the three progenies are very encouraging for their age, 16 years.

Table 13. *Nut yield (nuts/palm/yr.) of the progenies, tall x dwarf green, tall x tall and tall x san ramon with three fertilizer levels at Bandirippuwa and Ratmalagara in 2001.*

Progeny	Fertilizer level	Nut yield at BE Nuts/palm/year	Nuts yield at RE (nuts/palm/year)
TxDG	Recommended level	75	94
T x T		50	75
T x SR		56	68
TxDG	Half the recommended	74	107
T x T	Level	48	67
T x SR		46	62
TxDG	One and a half the	84	99
T x T	Recommended level	55	74
T x SR		41	74

The fruit components of the three progenies were assessed and the results are summarized in Table 14. *Tall x san ramon* recorded the biggest nuts at both sites weighing about 1200 g on average. Similarly husked nut, split nut and kernel weights too were significantly high in *tall x san ramon*. *Tall x tall* ranked 2nd for all fruit components with moderate weights but significantly higher than *dwarf green x tall*. The striking feature is the extremely high copra content in tall x san ramon nuts averaging almost 300 g/nut. In this experiment, the copra out turn of *tall x tall*, 266 g/nut is also remarkable. The overall copra out turn of the three progenies is given in table 15. *Tall x dwarf green,* once again demonstrated it's superiority in overall productivity, in spite of the low copra out turn per nut. *Tall x san ramon* ranked second inspite of high copra out turn for nut. The copra out turn in general is very high among all the crosses in this experiment than expected at this age.

Table 14. *Fruit components of the crosses tall x dwarf green, tall x tall and tall x san ramon at the sites Bandirippuwa and Ratmalagara.*

Site		Bandirippuwa	Ratmalagara	Average
Fruit component	Progeny			
Fresh nut weight (g/nut)	TxDG	1059	1362	1211
	TxT	1371	1621	1496
	TxSR	1640	1913	1777
Husked nut weight (g/nut)	TxDG	650	692	671
	TxT	818	841	830
	TxSR	981	889	935
Split nut weight (g/nut)	TxDG	500	531	516
	TxT	631	623	627
	TxSR	729	660	695
Kernel weight (g/nut)	TxDG	338	353	346
	TxT	404	407	406
	TxSR	479	434	457
Copra weight (g/nut)	TxDG	208	222	215
	TxT	262	269	266
	TxSR	314	285	300

Table 15. *Copra out turn of the crosses tall x dwarf green, tall x tall and tall x san ramon at the sites Bandirippuwa and Ratmalagara*

Mean yield of copra	Bandirppuwa			Ratmalagara		
	TxDG	TxT	TxSR	TxDG	TxT	TxSR
Mean yield (copra kg/ha/yr.)	3065	2465	2880	4193	3572	3704
Mean yield (copra kg/palm/yr.)	16	13	15	22	19	19
Mean yield (copra g/nut)	208	262	314	222	269	285
S E (copra g/nut)	5	6	5	5	6	5

J.M.D.T. Everard, W B S Fernando and R Jayatilleke

The progeny trials at the other three sites are not progressing well except the one at Daisy valley. The trial at the NLDB farm, Andigama is suffering badly due to very poor management. The yield records were not taken at Mangala eliya because

nuts were all consumed by monkeys at young stages. The trial at Daisy Valley is progressing well despite a section in the site being heavily water logged.

The yields at Andigama and Daisy Valley are given in Table 16. The yields show a decline in the year at the two sites in all the crosses. This probably is due drought conditions prevailed in the country. The cross *dwarf green x san ramon* looks very promising as it is yielding as good as *dwarf green x tall* or *tall x dwarf green* while maintaining bigger nut size an hardy characteristics of *san ramon.* Analysis of fruit components of these crosses will commence from 2002.

Two observation trials established at Sirikandura (1989; T x DG, T x T, T x SR and T x DY) and Ratmalagara (1989; DG x T, DY x T, DG x SR, and DT x SR) were monitored during the year. The status of these trials is poor although almost all the palms have attained flowering.

Table 16. *Nut yield (number of nuts/palm/yr.) of the progeny trials at Mangala Eliya, Andigama and Daisy Valley Estates.*

Cross	Nuts/palm/yr.					
	Mangala Eliya*		Andigama		Daisy Valley	
	2000	2001	2000	2001	2000	2001
T x DG	35		59	39	82	60
T x T	27		39	42	46	38
T x SR	33		48	29	48	41
T (OP)	28		--		--	--
DG x SR	--		--		78	57
DG x T	--		--		88	62

DG, dwarf green; T, tall; SR, San Ramon; T (OP), Tall (open pollinated)

Not recorded in year 2001

J.M.D.T. Everard, M.H.L. Padmasiri, R. Jayathilaka, W.B.S. Fernando, K. Ekanayake and N. Herath

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 certain extent. Although it is appropriate to commence recording of yields the different crosses, obtaining accurate data is unlikely because of heavy nut thieving as the palms are still young and bunches are within the ground's reach.

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

Project : COLLECTION CONSERVATION AND EVALUATION OF COCONUT GERMPLASM

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

Pre-prospection and collecting of germplasm continued during the year and new locations identified Aparakka, Digdenipotha and Bathigama from the Matara district. Seeds were collected from these sites and laid in the nursery while fruit components were analyzed from a sample of each collection (Table 17). Germination data were recorded at the nursery of all the collections to submit the data for Coconut Genetic Resources database along with the passport data.

Table 17. *Fruit component analysis of coconut accessions collected during 2000.*

Accession	Fresh nut wt. (g)	Husked nut wt. (g)	Split nut wt. (g)	Shell wt (g)	Kernel wt. (g)	Dry wt. (100g/nut)
Aparakka	1651	795	617	223	394	54.9
Digdenipotha	1405	688	541	196	345	54.6
Bathigama	1862	843	629	233	395	52.5

S.A.C.N. Perera, J.M.D.T. Everard and K. Ekanayake

The field gene banks at Bandirippuwa, Poththukulama, Lenawa and Raddegoda were maintained successfully. Growth measurements were recorded of the 13 accessions established at the Pallama Seed Garden. Kohombana Gene Bank located at Coconut Cultivation Board (CCB) premises, Gonagolla, Amparai was also making good progress with the ecotypes collected from the neighborhood despite extremely harsh weather conditions in the area. CCB was requested to expand the gene bank by adding the three accessions, Damana, Deegawapi and Kohombana from the Amparai district. 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 despite frequent drought periods observed during the year.

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 18.

Table 18. *Yield data of 10 germplasm accessions at the Poththukulama Gene bank (sample size = 30 palms)*

Accession	Age (Yr.)	Nuts/palm/year	
Year		2000	2001
Moorock	11	42	32
Palugaswewa	11	55	46
Pitiyakande	11	60	42
Clovis	10	43	40
Margaret	10	63	58
Kundasale dwarf	9	52	51
Namalwatta	8	63	56
St. Anne's	8	59	43
Cameroon Red Dwarf	7	13	12
Dwarf Brown	6	26	23

The status of field gene banks and various other conservation blocks as at 31st December 2001 are summarized in proceeding tables (Table 19 - Table 26).

Table 19. *The status of the Pottukulma Field Gene Bank as 31st December 2001(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	80	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	79	0	12	91
13. Melsiripura	78	0	13	91
14. Mangala Eliya	78	0	8	86
15. Goyambokka	77	0	13	90
16. Cameroon Red Dwarf	45	0	41	86
17. Goluwapokuna	72	0	9	81
18. Keenakelle	65	0	25	90
19. Dwarf Brown	28	0	74	102
20. Maliboda	78	0	12	90
21. Horakelle	65	0	25	90
22. Walahapitiya	68	9	8	85
23. Wellawa	58	1	20	79
24. Embryo Culture Plants	16	0	3	19
25. Brazillian Green Dwarf	16	0	23	39

Seedlings raised from open pollination of dwarf brown parents comprising natural selves and hybrids are present in this accession.

J.M.D.T. Everard, S.A.C.N. Perera and R.B. Attanayake

Table 20. *The status of the Kotakanada (Bandirippuwa) Field Gene Bank as at 31st December 2001 (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, S.A.C.N. Perera and R.B. Attanayake

Table 21. *The status of the Pallama Field Gene Bank as at 31st December 2001(Planted in 1999)*

Accession	Number of bearing	Number of young palms	Number of vacancies	Total planted
1. Thelidiriya (TLD)		51	2	53
2. Kalawewa (KL)		60	0	60
3. Ambakelle Special (AS)		59	1	60
4. Galadivulwewa (GDW)		60	0	60
5. Sindurupitiya (SP)		26	2	28
6. Wanathawillu (NM)		59	1	60
7. Ihala Kagama (IK)		57	3	60
8. Vijithapura (VJ)		60	0	61
9. Mahawelathenna (MWT)		53	1	54
10. Hangiliyagama (HNG)		59	1	60
11. Blackstone (BT)		53	4	57
12. Lanlib (LL)		56	4	60

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Table 22. The status of the Lenawa Field Gene Bank as at 31st December 2001(Planted in 1998)

Accession	*Number of flowering palms*	*Number of young palms*	*Number of vacancies*	*Total planted*
1. Sitrakala (SK)	5	77	2	79
2. Wilhelmina (WHM)	4	77	1	78
3. Kivulakelle (KK)	4	80	1	80
4. Thammenna ™	7	68	2	70
5. Yatawatta (YT)	8	64	6	70
6. Marandawila (MW)	5	79	2	80
7. Mirishena (MH)	25	40	3	60
8. Tall x Tall	3	79	1	80
9. Andigama (AND)	2	77	3	80
10. Dehigahalanda (DHL)	0	45	6	49
11. Dickwella (DW)	1	49	2	50
12. Haragama (HG)	0	62	3	65
13. Namalwatta (NM)	0	73	2	75
14. Deberayaya (DB)	0	63	13	75
15. Goyambokka (GB)	0	66	9	75
16. (Tissue Cultured)		7	15	22
16. Beliatta		6	16	22

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Table 23. *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		41	7	48
2. Galenbindunuwewa		53	5	58
3. Madagama		43	22	65
4. Millawana		37	28	65
5. Mahakumbukadawala		47	18	65
6. Beliatta		12	53	65
7. Wellawaya (G)		4	51	55
8. Raddegoda	1	15	34	50
9. Wellawaya (B)		39	5	44
10. Wakwella		38	7	45
11. Aluthwatta		28	22	50
12. Zoysawatta		58	18	76
13. Pamunugama		47	9	56
14. Sedawatta		53	24	77
15. Iranawilla		55	2	57
16. Adikarigoda		74	1	75
17. Yodakandiya		97	6	103
18 Magama		68	3	71

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Table 24. *The status of the Kohobana Field Gene Bank as at 31st December 2001(Planted in 1999/2000)*

Accession	*Total planted*
Magama	146
Wellawaya	57
Beliatta	62
Kivulakelle	165
Clovis	126
Debarayaya	160
Dickwella	95
T x T (HP)	203
Ambakelle special	137
Kirinda	146

J.M.D.T. Everard

Table 25. *The status of the indigenous tall coconut conservation block at Bandirippuwa as at 31st December 2001 (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 planted*
Ran thembili	24	6	8	38
Bodiri	42	1	37	80
Porapol	30	1	26	57
Nawasi	26	5	5	36
Kamandala	4	0	2	6
Gon thembili	52	1	16	69
Dikiri	1	0	2	3
San Ramon	148*		14	162

*41 of these are used for production of *san ramon* seedlings by cross pollinating with pollen collected from six selected *san ramon* palms from fields 4, 9 and 16 at BE for planting in the Pallama Seed Garden

J.M.D.T. Everard, G K Ekanayake, S. Mallawarachchi and M.H.L. Padmasiri

Table 26. *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 seedlings	Number of vacancies	Total planted
Dwarf green*	21		78	99
Dwarf yellow*	10		34	44
Dwarf red*	43		30	73
Mirishena dwarf (1998)	21	7	13	41
Brazilian green dwarf (1993)	28	6	43	77
Dwarf brown (1996)	11	16	18	45
Dwarf brown (1996 at RE)	43	23	44	110

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

Table 26 a. *The status of flowering of the nine germplasm accessions planted at Andigama farm (NLDB), Giriulla (1994)*

Name of accession	Number and percentage of palms in flower	Number of seedlings planted	Number of vacancies
Maliboda	8 (25%)	60	28
St Anne's	9 (36%)	60	35
Ambakelle special	5 (16%)	60	28
Margaret	8 (25%)	60	28
Moorock	5 (17%)	60	31
Deberayaya	4 (11%)	60	25
Walahapitiya	4 (11%)	60	25
CRIC60	5 (19%)	60	34
Clovis	5 (27%)	60	41

L. Perera and G K Ekanayake

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

King coconut seedlings raised 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.

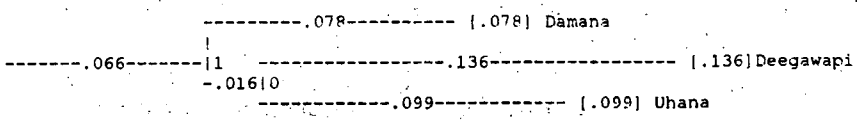
Forty individuals each from Marandawila, Walpita and Walahapitiya along with the open pollinated control from Marandawila (40 seedlings) were planted at Raddegoda in a randomized block design with 10 seedlings /plot. Fifty four seedlings from Marandawila, 25 from Walpita, 45 from Walahapitiya, 25 from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

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

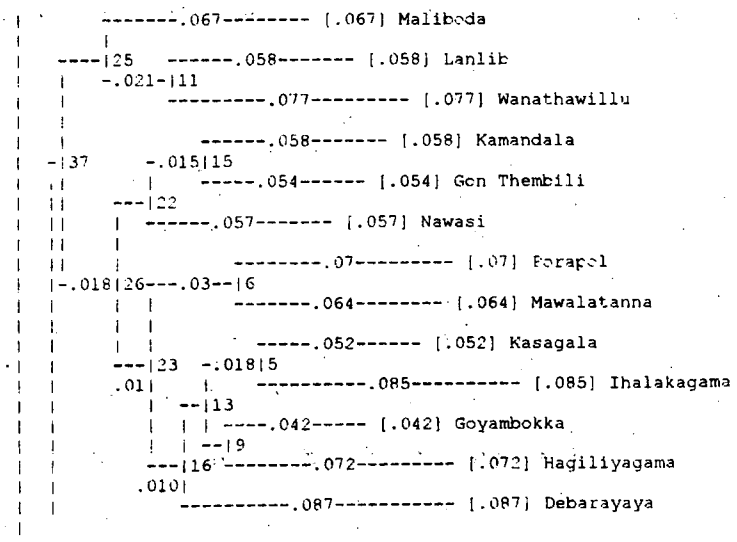
Project : MOLECULAR CHARACTERIZATION OF COCONUT GERMPLASM

Experiment 1 Randomly Amplified Polymorphic DNA (RAPD) based characterization of coconut germplasm

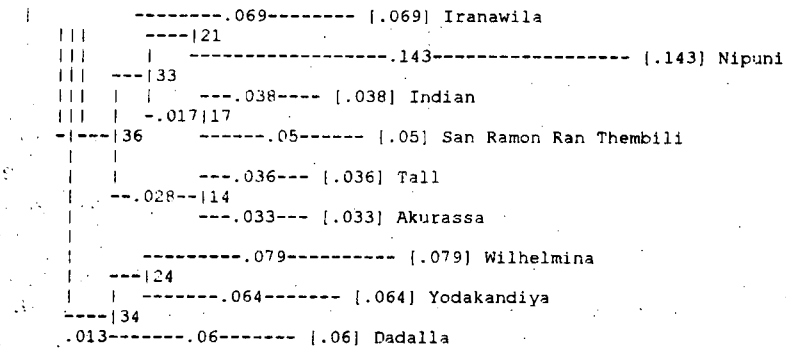
Forty-three accessions of coconut germplasm were characterized by detection of 166 RAPD fragments and the genetic relationships were assessed among the coconuts assayed. Following figure depicts the organization of the population structure of coconut in Sri Lanka.



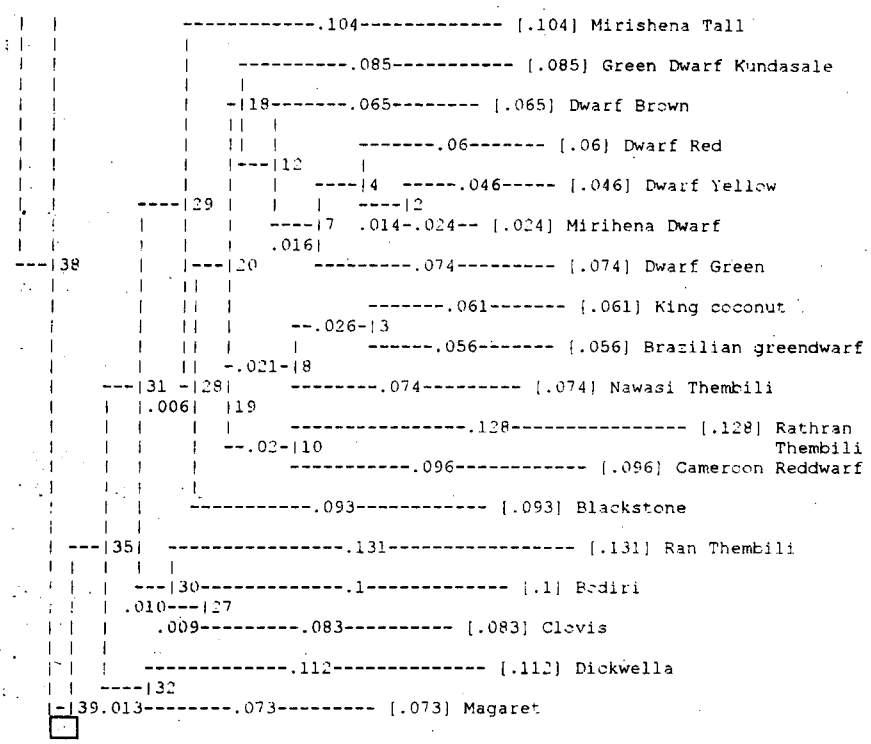
Group 1 - Three tall collections from Amparai district



Group 2 - Thirteen Sri Lanka tall collections



Group 3 - Nine tall collections with four accessions non-typical of Sri Lanka Tall (Nipuni, Indian, SR Ran Thembili and Wilhelmina



Group 4 - Eighteen accessions comprising all dwarf forms and San Ramon and San Ramon-like accessions

The RAPD assay show that the coconut in Sri Lanka basically fall into two groups, one representing the genome of African tall coconuts the other Pacific coconuts. All tall coconuts except the Philippine type, San Ramon and its derivatives fell into the former group while dwarf coconuts fell into the group constituting the Philippine types. Dwarf coconuts probably retained the original coconut genome due in part to its predominantly inbreeding reproductive behavior. Three germplasm accessions collected from ancient villages in Amparai shared a unique genome probably indicating a common source of origin somewhat different from domesticated coconuts in other parts of the country. DNA assay procedures were used further by applying SSRP and AFLP markers and although not conclusive the results showed parity with illustrating of the RAPD revealed genetic relationships of coconut in Sri Lanka. The overall results however, indicated the limited genetic variability available for further utilization as the three major categories, tall, dwarf and san ramon have already being harnessed in production of hybrids. This suggests the strong need for germplasm enrichment by introduction of exotic coconuts if at all a quantum increase in coconut productivity is expected by hybrid development. Deliberations were continued through COGENT and CESS assistance for importation of 23 germplasm accessions, nine from India, and six from Ivory Coast and eight from Fiji and PNG.

*J.M.D.T. Everard and N. Dasanayake**

**Lecturer, Department of Botany University of Sri Jayawardenepura*

PROJECT: MOLECULAR MARKER BASED MAPPING OF THE COCONUT GENOME

Experiment 1 Construction of a genome map using simple sequence repeat polymorphisms (SSRP) in a segregating population of selfed dwarf green x tall

This is a preliminary study undertaken to map the coconut genome and the initial attempt was with limited success as the existing mapping populations available at the CRI revealed inadequate even for constructing a frame work map. Therefore, a fresh pollination program was initiated to construct F_2 families of *dwarf green x tall* with known pedigree. Meanwhile development of molecular markers to discriminate *tall* and *dwarf* was continued with further emphasis on micro-satellite polymorphisms. Construction of the new laboratory for molecular biological studies at the CRI through CESS assistance is now in as near completion. A rapid expansion in molecular assay procedures for development of molecular markers and diagnosis of pathogens of unknown etiology in coconut is expected after the laboratory is adequately equipped. The work on FAO project for diagnosis of Rapid Decline Syndrome has already commenced with the collaboration of the Plant Physiology and Crop Protection Divisions.

1.2 Establishment of the Pallama Seed Garden

The Pallama seed garden inaugurated on 9th December 1998 for mass-producing CRSL98 (*tall x san ramon*) now comprises approximately 5000 seedlings (75 ac) of *tall* and *san ramon* planted in rows. The actual status of the seed garden is summarized in Table 33, a total of 3854 seedlings comprising of 3126 Tall and 728 San Ramon were planted up to 31 December 2000. Some of these are filling of vacancies. The details of planting at different stages are given in Table 27.

Table 27. *The status of planting in the new seed garden at Pallama as at 31st December 2001*

		VARIETY	*YEAR(S) OF PLANTING*	*SEEDLINGS PLANTED*
FIELD 1	Seed palms	Tall	1998-2001	710
		San Ramon*		333
	Guard row	San Ramon		1145
		Total		2188
FIELD 2	Seed palms	Tall	1999-2001	1058
		San Ramon		529
	Guard row	San Ramon		0
		Total		1587
FIELD 3	Seed palms	Tall	1999-2001	1236
		San Ramon		385
	Guard row	San Ramon		0
		Total		1621
		Grand Total		5396

*5 San Ramon seedlings have attained flowering

Outside Funded Projects

1. NRC Project on molecular pathogen diagnosis (2000 - 2002 NRC99-11 - J.M.D.T. Everard)
   Title: Molecular diagnosis of coconut disorders, leaf scorch decline syndrome (LDS), rapid decline syndrome (RDS) and premature decline syndrome (PDS) of unknown etiology

   All the equipment have been purchased from the funds allocated for the first year. The remaining funds were not yet released due to budget restrictions in the country.

2. CESS Project on Biotechnology (2000 - 2002 - J.M.D.T. Everard)

   Most of the equipment and chemicals specified under this project have been purchased. Two Ph.D. students are undergoing training on molecular diagnostics for which assistance is partly provided through this project. The FAO project on

similar objectives is also getting benefited by the equipment and chemicals obtained from this project.

3. ADB Science and Technology Project on Biotechnology (2000 - 2002 - J.M.D.T. Everard)

   Some equipment and most of the chemicals specified under this project have been obtained. More equipment are to be supplied. The two Ph.D. students undergoing training on molecular diagnostics under CESS project also get assistance is partly provided through this project. The FAO project on similar objectives is also being benefited by the equipment and chemicals obtained from this project.

2.4 Services offered to the public during the year 2001

Seeds of improved varieties produced:

CRIC60 and CRIC65:	1,475,761 of CRIC60 and CRIC65 at ISG 346,507 at Maduruoya
CRISL98:	3705 seedlings raised by hand pollination

A three-day program on planting materials, seed production, seed raising, planting and early care was conducted for Coconut Estates Managers

One-day program on planting materials, seed production, seed raising, planting and early care was conducted for coconut growers

J.M.D.T. Everard involved in supervision of three Ph.D. research programs on Plant Molecular Biology at the Gene Technology Unit of the University of Colombo.

J.M.D.T. Everard served as a visiting lecturer in Plant Breeding and Applied Genetics at the University of Sri Jayawardenepura.

Attended to growers' requests on numerous occasions on problems regarding planting material, seedlings, planting densities, planting depths etc.

ACKNOWLEDGEMENTS:

The cooperation and assistance of the research, technical and field staff of the Genetics & Plant Breeding Division is of very high standard during the year and they all deserve a note of appreciation. The excellent contribution of Mrs. I.N. Jayawardene, Clerk/Typist and Mr. A. G. Nandasena, Office Attendant of the division in maintaining office procedures during the year is also noteworthy.

REPORT OF THE SOILS AND PLANT NUTRITION DIVISION
Head - L.L.W. Somasiri, Ph D

1. General

The research programme of the Division was aimed at refining technology on nutrient management, particularly with locally available organic and inorganic materials, evaluating micronutrients requirement and developing irrigation techniques for coconut. During the year, the Division maintained sixteen on-going field experiments and commenced one new experiment.

The comparison of the effect of Eppawela Rock Phosphate (ERP) with that of Imported Rock Phosphate (IRP) and Triple Super Phosphate (TSP) on performance of young palms showed, no significant difference in leaf phosphorus concentration of the palms among treatments in the 10^{th} year of the experiment,. It implies that ERP can be equally good as IRP for young palms.

Substitution of the muriate of potash with sodium chloride for coconut palms on lateritic soils of the Wet zone did not cause a significant drop in nut yield after 4 years of continuous treatment application. Also, there was no effect on the yield or the nutrient status of the palms on loamy sand soils of the Dry-Intermediate region due to the substitution. The results further showed that the effect of sodium chloride and muriate of potash would vary with soil conditions. An experiment on studying the effect of fertilizer and ethrel application and irrigation on toddy yield at Bandirippuwa Estate showed that the toddy yield of palms increased due to ethrel application on the flower in addition to regular fertilizer application.

Application of fresh poultry manure coconut palms in a land containing deep loamy sand soils resulted in damaging the roots in the surface soils. However, coconut yield was not affected due to the root damage. In another experiment, significant improvements in soil physical properties were observed due to application of organic manure such as goat dung, cow dung or Gliricidia.

An experiment on application of drip irrigation to coconut showed 47% increase of nut yield of palms that received irrigation at the rate of 43 litres of water per day at 25 days interval compared to the control (no irrigation).

As service functions, the Division provided Differential Fertilizer Recommendation (DFR) to 138 growers during the year. For quality testing, 182 inorganic fertilizer samples, 13 organic manure samples and 200 coir dust samples were analysed. In addition, soil survey for land use evaluation was carried out in a number of land covering a total extent of 1000 ha. In addition to the research work, Division staff carried out advisory visits and participated in various training programmes.

2. RESEARCH PROJECTS

PROJECT 5.0 : DEVELOPMENT OF AN IMPROVED PACKAGE OF SOIL MOISTURE CONSERVATION PRACTICES FOR LAND SUITABILITY CLASSES 3, 4 AND 5 TO INCREASE YIELD BY 25%

Experiment 5.0.3 : Evaluation of the effect of husk pits on soil moisture conservation and yield increase of the coconut palm

This experiment was carried out as an observation trial to test the effect of different methods of husk burying on coconut yield. The experiment, on a randomized block design with 3 replicates and 6 palms (45 years old) per plot, was established in 1998 at the following locations.

Expt. No	Location region	Agro-ecological	Soil type	Land suitability class
5.0.3.1	Caran Estate, Bingiriya	IL_1	Andigama series	S_4
5.0.3.2	Muthugala Estate, Dambadeniya	IL_1	Kuliyapitiya series	S_4

The treatments were as follows.

T_1 - Control - mulch only
T_2 - Husks, buried in 1/3 circular trench
T_3 - 1/3 circular trench without husks but refilled with soil
T_4 - Husk buried in 8' x 4' x 2' pit
T_5 - Husks buried in 1/3 circular trench + mulch

The treatments were imposed in 1998. Application of 3 kg of APM and 1 kg of dolomite was carried out annually. The nut yield of both sites was recorded during the year. The yield data of both sites are given in Table1.

Table 1. *The nut yields in the experimental site at Caran Estate, Bingiriya and Muthugala Estate, Dambadeniya*

Treatment	Nut Yield (nuts/ha)			
	Caran Estate, Bingiriya		Muthugala Estate, Dambadeniya	
	Cumulative 1999/2000	2001	Cumulative 1999/2000	2001
T_1	19159	9664	14148	9585
T_2	16114	9787	18293	7926
T_3	16334	10770	17596	8716
T_4	18263	12113	17143	10375
T_5	17893	10366	19657	10928
CV	16.7%	18%	25%	20%
Significance ($P \leq 0.05$)	ns	ns	ns	ns

T_1 - Control - mulch only; T_2 - Husks, buried in 1/3 circular trench; T_3 - 1/3 circular trench without husks but refilled with soil; T_4 - Husk buried in 8' x 4' x 2' pit; T_5 - Husks buried in 1/3 circular trench + mulch

The mean yield of the treatment T_4 has slightly increased over the control in Carron Estate and the yields of treatments T_4 and T_5 have slightly increased in Mutugala Estate. However the differences were not significant.

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

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

This experiment, on a randomized block design with 3 replicates and 6 palms per plot, was established in 1991 on Andigama series soils at Ratmalagara Estate in IL_1 agro ecological region. The site falls into land suitability class S_4. The seedlings belonged to T x T variety.

The treatments of this experiment for the year 2001 consisted of three phosphate sources viz., triple super phosphate (TSP), saphos phosphate (SP) and Eppawela rock phosphate (ERP) applied in terms of P_2O_5 equivalents of 150 g, 300 g and 600 g (recommended dose is 180 g) per year respectively. The treatments were applied at 6 monthly intervals. Different P sources and levels of treatments are given in Table 2.

Table 2. *The sources of P, and the levels of treatments with the control*

Treatment	Level (rate) of application g/palm/y		
	L_1	L_2	L_3
TSP (46% P_2O_5)	326	652	1300
SP (27.5% P_2O_5)	545	1090	2180
ERP (30% P_2O_5)	500	1000	2000
(P_2O_5 equivalent)	(150)	(300)	(600)
Control	0	0	0

Basal application;	Urea	700 g/palm/y
	Muriate of potash	700 g/palm/y
	Kieserite	500 g/palm/y

Leaf samples, taken from 14th frond of each treatment, were analyzed for phosphorus. Soil samples, taken at 0-25 cm and 25-50 cm depths respectively from the manure circle of each treatment, were analyzed for available phosphorus by 2.5% acetic acid method. The data were analyzed statistically.

(i) P concentration

As seen from Table 3, the leaf P concentration of all treatments including the control was greater than the critical leaf P concentration (0.11%). Therefore phosphorus has not been limiting for all experimental palms irrespective of treatments. The differences of leaf P concentrations between the control and the rest of the

treatments, between phosphorus sources or between levels of each phosphate source were not significant.

The soil P extractable with 2.5% acetic acid was highly variable among treatments and between the two sampling depths. The differences of 2.5% acetic acid -P between the control and the rest of treatments were highly significant ($p < 0.001$). The mean values of 2.5% acetic acid - P of TSP treatments (74.6 mg/kg soil) were significantly different ($P < 0.001$) from the mean values of saphos phosphate treatments (183.5 mg/kg soil) and Eppawela rock phosphate treatments (186.7 mg/kg soil).

Table 3 : *Phosphorus concentration of the 14th leaf (percentage of dry matter) of palms and available phosphorus of soils of treatment plots in 2001*

Source	Treatment Level	% leaf P	2.5% Acetic acid extractable P (mg/kg)	
			0-20 cm depth	20-40 cm depth
TSP	1	0.116	21.7	7.8
	2	0.127	87.5	27.0
	3	0.120	114.9	93.4
SP	1	0.120	74.3	17.4
	2	0.114	139.4	25.8
	3	0.127	336.7	28.4
ERP	1	0.125	126.6	23.7
	2	0.130	186.1	29.4
	3	0.127	247.3	38.7
Control		0.113	4.4	3.6
LSD for p<0.001		ns	103.1	22.1

The difference of 2.5% acetic acid -P among the three saphos phosphate treatment levels were significantly different (Table 3). However, the differences of 2.5% acetic acid - P between the two rock phosphate (SP and ERP) treatments were not significant (Table 3). In all the treatments except the control, the 2.5% acetic acid - P at the 0-25 cm depth of soil was found to be significantly different from that of the 25-50 cm depth.

The overall results showed a significant increase in 2.5% acetic acid extractable P as a result of application of any of the three sources of phosphate. However, there was no significant increase in the leaf P concentration of the palms as a result of the increase of soil P.

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Experiment 6.0.3 : Evaluation of the efficiency of rock phosphates 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) under the weakly acidic or neutral pH level of the Dry zone soils. As a preliminary study, a pot experiment was established with four different soils according to the Complete Randomized Design with 3 replicates using following soil series.

Great Soil Group	Soil series	Agro-ecological region
Regosols	Mampuri	DL_3
Latosols	Gambura	DL_3
Reddish Brown Earth	Elayapattuwa	DL_3
Red Yellow Podzolic	Boralu	WL_3

Treatments were as follows.

T_1 - No fertilizer
T_2 - TSP 1 g/2.2 l of soil
T_3 - SP 1 g/1.3 l of soil
T_4 - ERP 1 g/1.3 l of soil
T_5 - HERP 1g/1.3 l of soil

All the pots were treated with a basal dose of urea, muriate of potash and dolomite at the rates of 2.88 g/pot, 5.76 g/pot and 3.60 g/pot respectively.

Rainfall records during last five years were collected from coconut estates situated close to the soil sampling sites. Each pot was watered according to the rainfall pattern existing in that particular sampling locations. Soil samples were taken from pots at 14 days interval after treatment application. The analysis of soil phosphorus in each sample is in progress.

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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- 2001)

This experiment, on a randomized block design with 3 replicates and 6 palms per plot, was established in 1997 at the following sites.

Expt. No	Location	Year of establishment	Soil type region	Agro-cological
6.1.1.1	Wayagolla (Gravelly loam)	1996	Boralu series	WL_3
6.1.1.2	Ganewatta (Sandy loam)	1996	Wariyapola series	IL_3

Palms at both sites were about 40 years old.

The treatments of this experiment are muriate of potash (1.6 kg/palm/y), potassium sulphate (1.8 kg/palm/y), sodium chloride (1.2 kg/palm/y), sodium sulphate (1.45 kg/palm/y) and a control (no potassium, sodium or chloride treatment). Each treatment plot was given a basal dose of ammonium sulphate (1.2 kg/palm/y) and saphos phosphate (0.6 kg/palm/y). At both sites, leaf and soil sampling and the treatment applications were completed in May 2001. The nut yields of both sites are given in Table 4.

Table 4. *The nut yields of experiments at Wayagolla and Ganewatta from 1997 to 2000 and 2001.*

	Wayagolla Estate nuts/palm/year		Ganewatte Estate nuts/palm/year	
	1997-2000 cumulative	2001	1997-2000 cumulative	2001
Control (T_1)	217	55.2	213	53.7
Muriate of potash (T_2)	252	66.8	183	53.0
Potassium sulphate (T_3)	235	67.0	223	49.0
Sodium chloride (T_4)	217	62.6	225	51.0
Sodium sulphate (T_5)	254	64.8	230	52.9
Level of significance		ns		ns

At Wayagolla site, the difference in nut yield between the control (T_1) and the other treatments, though not significant, gave some indication of a treatment effect. The difference in nut yield between potassium treatments (T_2 and T_3) and sodium treatments (T_4 and T_5) was also not significant at 5% level. However, the difference in nut yield between the control (T_1) and sodium treatments (T_4 and T_5), though not significant, gave some indication of the effect of sodium.

In contrast, at Ganewatte site, no difference among nut yield in treatments was observed. It could be due to the nature of the soil at Ganewatte site which is deep, sandy loam and imperfectly drained. The leaf nutrient status of both sites is shown in Table 5.

Table 5. *The leaf nutrient status of the 14th frond of palms in Wayagolla and Ganewatte sites in June, 2001; percentage in dry matter*

Treatment	Wayagolla					Ganewatte				
	K	Mg	Ca	Na	Cl	K	Mg	Ca	Na	Cl
Control	0.85	0.19	0.38	0.15	0.49	1.24	0.25	0.24	0.18	0.61
Muriate of potash	1.13	0.18	0.32	0.11	0.62	1.34	0.25	0.25	0.14	0.59
Potassium sulphate	1.14	0.17	0.27	0.15	0.51	1.33	0.24	0.26	0.14	0.63
Sodium chloride	0.56	0.23	0.35	0.31	0.46	1.20	0.25	0.23	0.21	0.60
Sodium sulphate	0.78	0.18	0.31	0.26	0.50	1.40	0.20	0.25	0.13	0.58
Level of significance	P<0.05	ns	ns	P<0.001	ns	ns	ns	ns	ns	ns
LSD	0.35	-	-	0.12	-	-	-	-	-	-

Data in Table 5 show that the difference in potassium concentration of the 14th frond between potassium treatments (T_2 and T_3) and sodium treatments (T_4 and T_5) in June were significant at 5% level. The potassium concentration of the 14th frond of the control was also lower than that of the potassium treatments (T_2 and T_3) but the difference was not significant. At the same time, the differences in leaf sodium concentration between sodium treatments and potassium treatments were highly significant in Wayagolla Estate. None of those differences were observed in leaf nutrient concentrations in Ganewatte Estate. It shows that the response of palms to sodium and potassium treatment applications on lateritic gravelly soils (Boralu series) is different to that on deep sandy soils (Wariyapola series).

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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

The experiment was established in 1991 with T x T seedlings planted on Andigama series soil at Ratmalagara Estate. As treatments, three levels of N (644 g, 1288 g, 2576 g) as urea, K (644 g, 1288 g, 2576 g) as muriate of potash and Mg (352 g, 624 g, 1248 g) as kieserite were combined in 3^3 factorial design with 3 replicates. Amounts of N, K and Mg applied correspond to each treatment are given in parenthesis. A basal application of 500g TSP/palm/year was given. The treatments tested were much higher than the recommended dosages for young palms.

Soil samples, taken at 0-25 cm depth from the manure circle, and leaf samples from 14th frond of each treatment combination were analyzed for chemical parameters. The soils were analyzed for exchangeable K and Mg and total N. The leaf samples were analyzed for N, K and Mg concentrations. All the data were analyzed statistically.

(i) Response of exchangeable K and total N of the soil to the treatments

The main effect of K treatments was a gradual and highly significant ($p < 0.001$) increase in exchangeable K concentration of the soil from K_1 to K_3 (Table 6). There were no main effects of N and Mg treatment levels or interaction effects on exchangeable K of the soil. The effect of N treatment level on total N of the soil was not significant although there was an increasing trend with increasing N treatment levels. There was no significant effect of K and Mg treatment combinations on total N of the soil too.

Table 6. *The main effects of the treatments on exchangeable K and total N of the soil*

Treatment level	Exchangeable K me/100g (mean of 27 observations)	Treatment level	Total N (mg/kg) (mean of 27 observations)
K_1 (644 g/y)	0.332 (± 0.109)	N_1 (644 g/y)	1294 (± 487)
K_2 (1288 g/y)	0.467 (± 0.157)	N_2 (1288 g/y)	1496 (± 743)
K_3 (2576 g/y)	0.851 (± 0.300)	N_3 (2576 g/y)	1689 (± 979)
Significance	P < 0.001	Significance	ns
LSD	0.108		

(Standard deviations are given in parenthesis)

(ii) Response of exchangeable Mg to the treatments

(a) Main effects

The main effect of Mg treatment levels on exchangeable Mg of the soil was highly significant ($p < 0.001$) showing a gradual increase from Mg_1 level to Mg_3 level (Table 7). The exchangeable Mg was higher corresponding to N_2 treatment level than the N_1 and N_3 treatment levels. The difference in exchangeable Mg of N_3 treatment was significantly lower than that of N_2.

Table 7. *Main effects of treatment levels on exchangeable Mg*

Treatment level	Exchangeable Mg me/100g (mean of 27 observations)	Treatment level	Exchangeable Mg me/100g (mean of 27 observations)
Mg_1 (312 g/y)	0.238 (± 0.018)	N_1	0.351 (± 0.142)
Mg_2 (624 g/y)	0.316 (± 0.092)	N_2	0.377 (± 0.227)
Mg_3 (1248 g/y)	0.453 (± 0.210)	N_3	0.280 (± 0.118)
Significance	P < 0.001	Significance	P< 0.05
LSD	0.076	LSD	0.076

(Standard deviations are given in parenthesis)

(b) Interaction between K and Mg treatments

There was a significant negative interaction ($p < 0.05$) of K and Mg treatment combinations on exchangeable Mg of the soil. The interaction was more prominent in combinations of K treatment levels with the Mg_3 treatment level. As seen in Table 8, there was a gradual decrease of exchangeable Mg of the soil with increasing K levels. The pattern was somewhat different in combinations of Mg_2 level with different K levels where exchangeable Mg correspond to K_2Mg_2 were higher than the K_1Mg_2 although the difference was not significant. The results show that exchangeable Mg of the soil has decreased due to high level of K treatment application particularly at high Mg treatment levels.

Table 8. *Interaction effect of K and Mg treatment combinations on soil exchangeable Mg (The values are given in the decreasing order)*

Treatment combination	Exchangeable Mg; me/100g (mean of 9 observations)
K_1Mg_3	0.563 (± 0.275)
K_2Mg_3	0.463 (± 0.061)
K_3Mg_2	0.350 (± 0.124)
K_3Mg_3	0.334 (± 0.112)
K_1Mg_2	0.311 (± 0.078)
K_1Mg_1	0.297 (± 0.164)
K_2Mg_2	0.278 (± 0.059)
K_3Mg_1	0.240 (± 0.093)
K_2Mg_1	0.178 (± 0.038)
Significance	$p < 0.05$
LSD	0.076

(Standard deviations are given in parenthesis)

(iii) Response of leaf N and K concentrations to the treatments

The main effect of N treatment levels on the leaf N concentration was not significant. But the main effect of Mg treatment levels on the leaf N concentration was significant ($p < 0.05$) causing a decrease at Mg_3 treatment level (Table 9).

Table 9. *The main effects of N and Mg treatment levels on leaf N concentration*

Treatment level	% Leaf N (mean of 27 observations)	Treatment level	% Leaf N (mean of 27 observations)
N_1 (644 g/y)	2.07 (± 0.20)	Mg_1 (312 g/y)	2.11 (± 0.20)
N_2 (1288 g/y)	2.17 (± 0.23)	Mg_2 (624 g/y)	2.17 (± 0.17)
N_3 (2576 g/y)	2.08 (± 0.20)	Mg_3 (1248 g/y)	2.04 (± 0.24)
Significance	ns	Significance	P<0.05
LSD	-	LSD	0.105

All the leaf N levels were above the critical concentration of 1.9%.

Table 10. *The main effects of K treatment levels on leaf K concentration*

Treatment level	% Leaf K (mean of 27 observations)
K_1 (644 g/y)	1.35 (± 0.186)
K_2 (1288 g/y)	1.50 (± 0.165)
K_3 (2576 g/y)	1.72 (± 0.176)
Significance	P < 0.001
LSD	0.103

(Standard deviations are given in parenthesis)

The mean values of all K treatment levels were above the critical concentration for leaf K (1.2%). The leaf K concentration showed a gradual increase with increasing K treatment levels (Table 10).

(iv) Response of leaf Mg concentration to the treatments

(a) Main effects

There were two significant main effects of treatment levels. Firstly, the leaf Mg concentration significantly increased ($P < 0.001$) with increasing Mg treatment level. Secondly, the leaf Mg concentration significantly decreased ($p < 0.05$) from K_2 treatment level to K_3 treatment level (Table 11).

Table 11. *Main effects of Mg and K treatment levels on leaf Mg concentration*

Treatment level	% Leaf Mg (mean of 27 observations)	Treatment level	% Leaf Mg (mean of 27 observations)
Mg_1 (312 g/y)	0.165 (± 0.031)	K_1 (644 g/y)	0.194 (± 0.032)
Mg_2 (624 g/y)	0.186 (± 0.027)	K_2 (1288 g/y)	0.194 (± 0.043)
Mg_3 (1248 g/y)	0.205 (± 0.044)	K_3 (2576 g/y)	0.168 (± 0.035)
Significance	P < 0.001	Significance	P< 0.05
LSD	0.0.16	LSD	0.016

(Standard deviations are given in parenthesis)

(b) Interactions among K, Mg and N treatments

There was a negative interaction between K and Mg treatments on leaf Mg concentration. As seen from Table 12, when K_3 treatment level combined with Mg_1, Mg_2 and Mg_3 treatment levels, it imposed a decreasing effect on leaf Mg concentration. But K_2Mg_3 combination resulted in significantly higher leaf Mg concentration than K_1Mg_3. There was no significant difference between the leaf Mg concentration in K_1Mg_2 and K_2Mg_2 combinations. However, the leaf Mg concentration in K_3Mg_2 was significantly lower than that in K_2Mg_2.

Table 12. *Interaction effect of K x Mg treatment combinations on leaf Mg concentration (The values are arranged in the decreasing order)*

Treatment combination	% Leaf Mg (mean of 9 observations)
K_2Mg_3	0.229 (± 0.042)
K_1Mg_3	0.200 (± 0.044)
K_1Mg_2	0.196 (± 0.026)
K_2Mg_2	0.190 (± 0.035)
K_3Mg_3	0.189 (± 0.040)
K_1Mg_1	0.189 (± 0.026)
K_3Mg_2	0.174 (± 0.015)
K_2Mg_1	0.163 (± 0.023)
K_3Mg_1	0.143 (± 0.028)
Significance	P< 0.05
LSD	0.015

(Standard deviations are given in parenthesis)

The leaf Mg concentrations of different combinations of the Mg_1 treatment level with K_1, K_2 and K_3 treatment levels resulted in gradual decrease from K_1 to K_3. The results showed that the leaf Mg concentration at Mg_1 and Mg_2 treatment levels decreased when combined with increasing K treatment levels. However, at Mg_3 level, the trend was different. The K_2Mg_3 combination resulted in a higher leaf Mg concentration than the other K and Mg treatment level combinations.

There was a highly significant N x K x Mg treatment interaction on leaf Mg concentration. The leaf Mg concentrations greater than 0.2% which are corresponding to different N, K and Mg combinations are listed in Table 13. The K_2Mg_3 treatment, in combination with N_2, resulted in the highest leaf Mg concentrations whereas the K_2Mg_3 treatment combined with N_1 and N_3 resulted in low leaf Mg concentrations respectively, which were significantly lower than the former.

Table 13. *Interaction effects of N x K x Mg treatment levels on leaf Mg concentration*

Treatment combination	% Leaf Mg (mean of 9 observations)
$N_2K_2Mg_3$	0.250 (± 0.034)
$N_1K_1Mg_3$	0.230 (± 0.010)
$N_3K_3Mg_3$	0.226 (± 0.030)
$N_1K_2Mg_3$	0.220 (± 0.036)
$N_3K_2Mg_3$	0.217 (± 0.060)
$N_3K_1Mg_2$	0.213 (± 0.041)
$N_1K_2Mg_2$	0.213(± 0.041)
$N_2K_1Mg_3$	0.210 (± 0.026)
$N_2K_1Mg_1$	0.203 (± 0.005)
$N_3K_2Mg_2$	0.200 (± 0.045)
Significance	P < 0.01
LSD	0.0157

(Standard deviations are given in parenthesis)

The effect on the leaf Mg concentration due to the interaction between N treatment levels and K and Mg treatment combinations was rather irregular. However, only Mg_3 treatment level could maintain the leaf Mg concentration above 0.22% with some combinations of N and K treatments. Only $N_2K_2Mg_3$ combination could increase the leaf Mg concentration to the critical value of 0.25%. In this treatment combination, leaf N concentration was 2.09% and leaf K concentration was 1.46%, both of which were above the critical levels.

The overall results show that maintenance of leaf Mg concentration at the critical level is problematic. However $N_2K_2Mg_3$ is the only combination that could maintain the three nutrients at their respective critical levels.

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Experiment 7.0.2.: Formulation of a suitable fertilizer mixture, irrigation and ethrel levels for palms in tapping continuously or seasonally

This experiment was established in November 1998 at Bandirippuwa Estate (IL_1, Sandy loam, S_2) in a factorial design with 3 replicates and with three fertilizer treatments, two irrigation treatments and two ethrel treatments. There were four effective palms per plot. The treatments were as follows.

No Fertilizer	(FL0)	-	Control for fertilizer treatments
Fertilizer 1	(FL1)	-	Equal to nutrient removal by toddy & other parts (N = 460 g, P_2O_5 = 248 g, K_2O = 1890 g and MgO = 100 g)
Fertilizer 2	(FL2)	-	1 1/2 times of FL1 treatment
No irrigation	(IL0)	-	Control for irrigation treatment
Irrigation	(IL1)	-	Watering to 80% of field capacity
No ethrel	(EL0)	-	Control for ethrel treatment
Ethrel	(EL1)	-	Application of 2.5% ethrel solution on the flower

Yields were obtained as sweet toddy that was measured daily upto December 1999. The yield was daily measured as fermented toddy with effect from January 2000.

The irrigation treatments were applied when soil water status dropped to 50% of the field capacity using Tensiometer readings. The moisture status of the topsoil dropped to 50% of the field capacity within few weeks in the month of February and March in 2001. Ethrel was once applied to every emerging inflorescence. Toddy yield of each flower was measured separately.

After the 2nd fertilizer treatment application, statistical analysis of monthly toddy yield data indicated that there were significant differences ($p<0.05$) in toddy yields between some treatments (Table 14).

Table 14. *Toddy yield data in the months of November, December, April and May*

Treatment	Mean toddy yield l/palm/year			
	November 2000	December 2000	April 2001	May 2001
T_1 - FL_0 IL_0 EL_0	31.9	29.8	36.3	36.1
T_2 - FL_0 IL_0 EL_1	33.7	49.1	37.9	45.9
T_3 - FL_0 IL_1 EL_0	44.5	43.3	41.9	44.3
T_4 - FL_0 IL_1 EL_1	38.1	36.8	41.6	40.9
T_5 - FL_1 IL_0 EL_0	48.9	52.6	63.2	60.9
T_6 - FL_1 IL_0 EL_1	44.4	50.4	51.2	52.3
T_7 - FL_1 IL_1 EL_0	55.4	53.2	70.6	73.9
T_8 - FL_1 IL_1 EL_1	61.6	49.9	60.1	60.3
T_9 - FL_2 IL_0 EL_0	65.5	49.6	50.4	49.1
T_{10} - FL_2 IL_0 EL_1	53.1	52.0	58.6	70.7
T_{11} - FL_2 IL_1 EL_0	48.9	41.5	65.5	60.5
T_{12} - FL_2 IL_1 EL_1	68.5	73.3	73.9	75.8
Significance	$p \leq 0.05$		$P \leq 0.05$	
LSD	17.54	11.54	11.60	12.88

However, the differences in the total yield of toddy in the year among the treatments were not significant at 5% level. Nevertheless, the highest toddy yield was obtained from treatment T_{12} that was the highest fertilizer, irrigation and ethrel treatment combination (Table 15) which was equivalent to 1 1/2 times N, P, K and Mg removal by toddy per year.

Leaf samples from the 14 th frond were taken from each treatment at the end of November 2001 for nutrient analysis. All the nutrients except Mg, Ca, Cu and Zn were within their sufficiency ranges. The data are given in Table 16. However, Ca was indirectly applied along with rock phosphates but Zn and Cu were not included in the fertilizer treatments. Leaf K concentration was higher in treatments T_5 to T_{12}, which were corresponding to the 1st and the 2nd level of the fertilizer treatments respectively.

In general the toddy yield of fertilizer plus ethrel application treatments were higher than that of other treatments but the differences were not significant at 5% level (Table15). The overall data of the experiment indicated that ethrel and irrigation treatments along with fertilizer application were beneficial for increasing the toddy yield. The differences were not significant due to high variation of toddy yields. The experiment was terminated in September 2001.

Table 15. *Toddy yield data of the palms from October 2000 to September 2001*

Treatments	Mean Toddy yield l/palm/year
T_1 - FL_0 IL_0 EL_0	546.4
T_2 - FL_0 IL_0 EL_1	576.8
T_3 - FL_0 IL_1 EL_0	529.3
T_4 - FL_0 IL_1 EL_1	419.0
T_5 - FL_1 IL_0 EL_0	622.4
T_6 - FL_1 IL_0 EL_1	542.4
T_7 - FL_1 IL_1 EL_0	671.1
T_8 - FL_1 IL_1 EL_1	585.8
T_9 - FL_2 IL_0 EL_0	472.8
T_{10} - FL_2 IL_0 EL_1	583.4
T_{11} - FL_2 IL_1 EL_0	577.3
T_{12} - FL_2 IL_1 EL_1	655.5
Significance	ns

Table 16. The *leaf nutrient concentration of the 14th frond of the tapping palms receiving different treatments.*

Treatment	N %	P %	K %	Ca %	Mg %	Na %	Fe mg/kg	Mn mg/kg	Cu Mg/kg	Zn Mg/kg
T_1	2.19	0.146	1.37	0.21	0.28	0.22	62.1	78.1	3.03	22.2
T_2	2.17	0.135	1.20	0.30	0.25	0.21	70.5	87.5	3.49	21.0
T_3	2.29	0.131	1.24	0.29	0.28	0.17	63.8	74.6	3.75	27.6
T_4	2.12	0.138	1.19	0.28	0.28	0.17	93.3	69.6	3.53	20.6
T_5	2.03	0.132	1.40	0.29	0.22	0.13	66.8	92.1	3.85	17.9
T_6	2.19	0.129	1.42	0.30	0.24	0.19	76.3	96.0	4.05	22.2
T_7	2.49	0.135	1.47	0.29	0.23	0.15	78.3	93.5	3.58	23.0
T_8	2.20	0.155	1.32	0.29	0.25	0.20	86.0	83.1	4.54	18.1
T_9	2.19	0.145	1.43	0.33	0.27	0.18	72.3	91.7	3.35	27.9
T_{10}	2.50	0.137	1.57	0.29	0.22	0.15	80.9	93.6	5.19	26.3
T_{11}	2.16	0.125	1.50	0.30	0.22	0.16	72.5	94.2	4.54	21.7
T_{12}	2.21	0.126	1.51	0.31	0.23	0.13	89.7	99.7	4.86	18.5

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Experiment 7.0.3. Formulation of a suitable fertilizer recommendation for king coconut (1997-2002)

This experiment, on a randomized block design with 4 replicates and 4 palms per plot and six treatments was established on adult palms in 1997 at the following two locations.

Expt. No.	Location	Agro ecological region	Soil type	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

The age of palms at Marandawila was 17 years while that of Walpita was 21 years.

The fertilizer treatments are given in Table 17.

Table 17. *N, P, K and Mg treatment combinations of the experiment*

Treatment	Rate of application g/palm/6 month			
	Urea (g)	SP (g)	MOP (g)	Dolomite (g)
T_1	-	-	-	-
T_2	400	250	650	400
T_3	600	375	1000	600
T_4	800	500	1350	800
T_5	400	300	800	500
T_6	600	450	1200	750

The mean nut yields of Marandawila and Walpita sites are given in Table 18.

Table 18. *The nut yields at Marandawila and Walpita*

Treatment	Marandawila nuts/palm		Walpita nuts/palm	
	Cumulative yield from 1998-2000	2001	Cumulative yield from 1997-2000	2001
T_1	339	117	204	133
T_2	324	124	244	186
T_3	384	128	259	183
T_4	317	124	239	164
T_5	290	112	240	186
T_6	-	-	245	194
Level of Significance		ns		$p < 0.05$
LSD		-		32

T_1 - Control - no fertilizer; T2 - NPK removal/6 months; T3 - 1.5 times NPK removal/6 months; T_4 - 2 times NPK removal/6 months; T5 - APM; T6 - 1.5 times APM

At Walpita site, the yield difference between the treatments and the control was significant at 5% level. NPK and Mg treatments showed that there was a 37.5% increase of nuts (7870 nuts/ha/y) over the control. However, there was no significant difference in the nut yield between different NPK and Mg treatments at the end of the 4th year. At Marandawila site, there was no significant difference in nut yield even between fertilizer treatments and the control.

Table 19. *Leaf nutrient concentration of the 14th frond at Walpita site as at May 2001 (percentage of dry matter)*

Treatment	N	P	K	Na	Ca	Mg
T_1	1.96	0.120	0.98	0.07	0.18	0.18
T_2	1.97	0.120	1.23	0.07	0.17	0.14
T_3	2.01	0.120	1.12	0.06	0.20	0.13
T_4	2.04	0.115	1.15	0.07	0.19	0.14
T_5	1.97	0.116	1.05	0.08	0.19	0.16
T_6	1.99	0.117	1.18	0.07	0.18	0.14
Level of Significance	ns	ns	ns	ns	ns	ns

The differences in leaf nutrient concentrations of the 14th frond between the control (T_1) and the rest of the treatments were not significant at 5% level. The leaf nutrient concentrations among different treatments were also not significantly different. However, Ca, Mg and Na concentrations were far below their critical levels (0.25%, 0.35% and 0.1% respectively). Despite the regular dolomite application, the leaf Mg concentration of all the plots remained below 0.25% (critical level) since the commencement of the experiment (Table 19). It follows that the dolomite application as a treatment has not been effective in this experiment.

The leaf Ca concentration was below 0.24% in all the treatment plots at the beginning of the experiment and it never increased during 1998-2001 although rock phosphate, which is a component of the fertilizer treatments, contained about 4% of Ca. The Na concentration also remained below 0.1% since the beginning of the experiment. The low concentrations of Ca, Mg and Na in the 14th leaf may indicate deficiency of the respective elements in the experimental palms, which would have hindered the uptake of other nutrients also.

Table 20. *N P K and Mg concentrations of topsoil (0-25 cm depth) and subsoil (25-50 cm depth) of each treatment of Walpita site as at January 2001*

	Total N mg/kg		Available P mg/kg		Exchangeable K me/100g		Exchangeable Mg me/100g	
Treatment	T	S	T	S	T	S	T	S
T_1	1414	1053	40.6	12.4	0.38	0.28	0.84	0.62
T_2	1454	1147	309.5	39.1	0.83	0.50	1.06	0.81
T_3	1560	1147	267.0	32.1	0.76	0.45	1.22	0.66
T_4	1534	1000	446.0	22.4	1.09	0.60	1.42	0.56
T_5	1534	1080	321.7	60.9	1.04	0.43	1.09	0.51
T_6	1440	1200	175.0	41.7	0.78	0.60	0.50	0.26
Level of Significance	ns	ns	p =0.01	p=0.05	p=0.05	p=0.001	ns	ns
LSD			171.6	24.2	0.44	0.27		

T - Topsoil; S – Subsoil

After three years of treatment application, only available P and exchangeable K concentrations of the soil in the manure circle showed significant increase over the control (Table 20). There was no significant increase in both total N and exchangeable Mg concentrations of the soil. It appears that the rate of Mg fertilizer application should be further increased to obtain a significant difference between the control and the treatments.

Table 21. *Nutrient concentration of leaf in the 14th frond as percentage of dry matter of Marandawila site as at June 2001*

Treatment	N	P	K	Na	Ca	Mg
T_1	2.13	0.124	0.86	0.19	0.19	0.19
T_2	2.08	0.128	1.01	0.16	0.19	0.18
T_3	2.06	0.130	1.07	0.15	0.18	0.18
T_4	2.10	0.127	0.91	0.19	0.19	0.18
T_5	2.09	0.126	1.06	0.15	0.20	0.17
Level of Significance	ns	ns	ns	ns	ns	ns

As seen from Table 21, Ca and Mg concentrations of the 14th frond was below the critical levels (0.35% for Ca and 0.25% for Mg respectively). K concentration of the 14th frond was slightly higher in the fertilizer treatments compared to the control but the difference was not significant.

Table 22. *N P K and Mg concentrations of topsoil (0-25 cm depth) and subsoil (25-50 cm depth) of each treatment of Marandawila site as at January 2001*

	Total N mg/kg		Available P mg/kg		Exchangeable K me/100g		Exchangeable Mg me/100g	
Treatment	T	S	T	S	T	S	T	S
T_1	334	213	175	29.1	0.20	0.17	0.51	0.23
T_2	320	240	197	33.3	0.22	0.19	0.49	0.21
T_3	266	307	256	40.3	0.20	0.20	0.54	0.21
T_4	387	293	149	32.0	0.21	0.17	0.56	0.27
T_5	307	320	168	31.3	0.12	0.16	0.40	0.25
Level of Significance	ns	ns	ns	ns	ns	ns	ns	ns

T - Topsoil; S - Subsoil

Compared to soil nutrient concentrations of Walpita site, the concentrations of total N, exchangeable K and exchangeable Mg of Marandawila site were low in all the fertilizer treatments. The nutrient concentrations of the soil of Marandawila site have not increased over the control even after 3 years of 6 monthly fertilizer application (Table 22).

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

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

The objectives of this experiment are 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 to gather data on soil, plant and fertilizer rates to develop criteria for coconut palms in high potential lands.

This experiment, on a randomized block design with 3 replicates and six palms per plot, was commenced at the following locations.

Expt. No.	Location	Agro ecological region	Soil series	Year of commencement	Land suitability class
7.1.2.1	Madampe	IL_1	Madampe series	1999	S_1
7.1.2.2	Mawathagama	IL_1	Kurunegala series	2000	S_2
7.1.2.3	Mangala-eliya	DL_1	Borupan series	2000	S_2
7.1.2.4	Ganewatta	IL_3	Wariyapola series	2000	S_3
7.1.2.5	Udugama	IL_3	Andigama series	2000	S_4

The treatments for the all sites are given in Table 23.

Table 23. *Treatment combinations in the experiment (g/palm/y)*

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

The 2nd fertilizer application was done in January 2001. Leaf and soil sampling was done quarterly during the year.

Experiment 7.1.2.1 - Madampe

The yield data at Madampe site is given in Table 24.

Table 24. *The nut yield in the year 2000 and 2001 at Madampe site*

Treatment	Year 2000 Nuts/ha/year	Year 2001 Nuts/ha/year
T_1	10268	8767
T_2	12223	10886
T_3	8751	9970
T_4	9058	10343
T_5	10332	11481
Level of significance	ns	ns

The recording of copra yield was disturbed by the financial restrictions in the latter part of the year. In the year 2000, the overall mean yield of the palms that received fertilizer treatments was 10091 nuts/ha/y whereas that of the control was 10268 nuts/palm/y. However in the year 2001, the mean yield of the control has dropped by 14.6% whereas that of palms receiving fertilizer treatments dropped only by 5.7%.

The total N, 2.5% acetic acid extractable P and exchangeable bases of soil samples of the manure circle are given in Table 25. The difference ($p \leq 0.05$) in total soil N between the control and the rest and between treatment levels were significant. There was no significant difference of the concentration of the other nutrients between treatments (Table 25).

There was no significant difference in the nutrient concentrations in the 14th leaf of the palms due to treatment application in Madampe site. As seen from Table 25 (a), there has been an increase only in K percentage from 3 months to 6 months after fertilizer application. Although, Mg and Ca status was slightly below the critical level in most of the treatments, N, P, K and Na status were above the critical level for all the treatments.

Table 25. *Nutrient concentrations of the soil of Madampe site (mg/kg soil)*

Treatment	Total N		Available P		Exch K		Exch Na		Exch Ca		Exch Mg	
	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm
T_1	777	725	544	191	248	261	20	21	176	112	56	35
T_2	862	793	480	468	190	152	18	21	144	119	45	38
T_3	917	855	536	301	322	267	25	17	237	138	64	48
T_4	1012	930	770	314	250	144	22	19	193	148	53	50
T_5	1115	937	725	321	344	134	24	22	202	124	66	41
Significance ($p \leq 0.05$)	*	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
LSD ($p \leq 0.05$)	54.44	70.23	-	-	-	-	-	-	-	-	-	-

Table 25 a. *Nutrient concentrations in the 14th frond of the palms in different treatments - Madampe site*

Treatments	3 months after 2nd year fertilizer application						6 months after 2nd year fertilizer application					
	N%	P%	K%	Mg%	Ca%	Na%	N%	P%	K%	Mg%	Ca%	Na%
T_1	2.19	0.150	1.37	0.23	0.28	0.15	2.21	0.159	1.41	0.21	0.28	0.19
T_2	2.31	0.155	1.42	0.24	0.26	0.17	2.30	0.156	1.48	0.23	0.26	0.16
T_3	2.15	0.132	1.12	0.23	0.27	0.15	2.22	0.137	0.38	0.26	0.28	0.11
T_4	2.39	0.155	1.59	0.20	0.31	0.11	2.37	0.159	1.68	0.26	0.33	0.16
T_5	2.37	0.143	1.26	0.24	0.27	0.16	2.33	0.154	1.47	0.24	0.24	0.16

7.0.0.0 Siriwasa Estate, Mangala-eliya

The preliminary sampling of soil and leaf was done in January 2001 and the 1st treatment application was made afterwards. The nut yield data from January 2001 to December 2001 are given in Table 26. There was no significant difference in nut yield between treatments

Table 26. *The nut yield of Mangala-eliya site in 2001*

Treatment	Nut yield ha/year
T_1	9163
T_2	9392
T_3	9972
T_4	9358
T_5	9205
Level of Significance	ns

At Siriwasa estate, the difference ($p \leq 0.05$) in the total N, exchangeable K and exchangeable Na concentrations at 0-25 cm depth of the soil respectively between the control and the other treatments were significant. In the case of total soil N, there was a significant difference ($p \leq 0.05$) between the control and the other treatments at the depth of 25 - 50 cm too (Table 27).

Table 27. *Nutrient concentrations of the soil of Siriwasa estate (mg/kg soil)*

Treatments	Total N		Exchangeable K		Exchangeable Na		Exchangeable Ca		Exchangeable Mg	
	0-25 cm	25 -50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm
T_1	754	703	46	38	14	16	256	167	78	68
T_2	821	785	210	152	16	17	314	206	101	75
T_3	882	841	234	171	18	19	231	151	97	65
T_4	949	893	492	299	25	24	365	226	134	96
T_5	1036	975	407	315	21	24	323	299	121	99
Significance ($p \leq 0.05$)	*	*	*	ns	*	ns	ns	ns	ns	ns
LSD ($p \leq 0.05$)	50.92	97.72	102.53	-	6.07	-	-	-	-	-

There was no significant difference in the nutrient concentrations in the 14th leaf of the palms due to treatment application in Siriwasa Estate. As seen from Table 27 (a) N and K status were below the respective critical levels of those nutrients (1.9% and 1.2%) up to 6 months after 1st manuaring. The average nut production of 59 nuts per palm in 2001 (Table 26) in this site indicates that the yield is below the potential (S_2). It could be due to the N and K deficiency in the site. This situation is expected to improve with further treatment application.

Table 27 (a). *Nutrient concentrations in the 14th frond of the palms in different treatments - Siriwasa Estate*

Treatments	3 months after 1st manuring						6 months after 1st manuring					
	N%	P%	K%	Mg%	Ca%	Na%	N%	P%	K%	Mg%	Ca%	Na%
T_1	1.87	0.118	0.76	0.36	0.41	0.19	1.84	0.119	0.76	0.32	0.37	0.18
T_2	1.93	0.123	0.88	0.30	0.38	0.18	1.76	0.121	0.76	0.29	0.31	0.15
T_3	1.88	0.124	0.80	0.34	0.35	0.17	1.79	0.122	0.85	0.30	0.37	0.14
T_4	1.84	0.118	0.76	0.32	0.39	0.17	1.73	0.119	0.71	0.30	0.37	0.15
T_5	1.90	0.125	0.77	0.38	0.43	0.16	1.88	0.122	0.75	0.32	0.44	0.15

7.1.2.3 Udugama

Since this site was abandoned due to management difficulties and another site was selected from Marapola at Naiwala. The yield data recording from the selected palms at the new site is in progress.

7.1.2.4 Mawathagama

This site was selected to represent Kurunegala series soils but was abandoned later because the Coconut Cultivation Board wanted the selected block for seed nut production. Another site was selected for Kurunegala series from Wellawa.

7.1.2.5 Ganewatte

Site selecting is in progress.

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

Experiment 7.2.1: Determination of critical levels for Zn and Cu in the coconut palm (1997 - 2002)

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

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

The treatment combinations of $ZnSO_4.7H_2O$ and $CuSO_4.5H_2O$ and the cumulative yields of both sites are presented in Table 28. The basal doses for all treatment palms were 3 kg of APM and 1 kg of dolomite per palm.

There was no significant difference in the cumulative yield from 1998 to 2000 and yield in the year 2001 at both Pottukulama and Ratmalagara Estates. The Cu and Zn concentrations of the manure circle soils taken from different treatment combinations before the 4th treatment application are given in Table 29.

Table 28. *The treatmnt combinations and the average nut yield*

	Treatments		Pottukulama site		Ratmalagara site	
	$CuSO_4$ g/palm	$ZnSO_4$ g/palm	Cumulative yield from 1998 to 2000	2001	Cumulative yield from 1998 to 2000	2001
T_1	-	-	288	93.8	258	99.8
T_2	50	100	290	96.1	237	97.0
T_3	50	200	266	88.3	244	107.3
T_4	100	100	276	88.8	233	96.3
T_5	100	200	263	92.6	238	102.0
T_6	200	400	289	102.5	238	90.3
Level of Significance			ns	ns	ns	ns
CV			20%	22%	13%	17%

Table 29. *The Cu and Zn concentrations of the manure circle soils of each treatment before the 4th treatment application*

No.	Pottukulama site				Ratmalagara site			
	Cu mg/kg		Zn mg/kg		Cu mg/kg		Zn mg/kg	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
T_1	1.67^{a}	1.77	1.2^{a}	0.86^{d}	0.856^{a}	0.72^{bc}	1.54^{a}	2.33^{a}
T_2	5.54^{ac}	4.71	13.1^{ac}	3.18^{cb}	7.22^{b}	1.64^{bc}	14.90^{a}	2.54^{a}
T_3	14.6^{abc}	5.66	29.6^{ac}	2.81^{cb}	9.78^{b}	2.09^{b}	40.00^{b}	10.10^{a}
T_4	14.9^{abc}	5.43	14.1^{ac}	2.29^{c}	9.40^{b}	1.92^{b}	12.97^{a}	3.45^{b}
T_5	15.9^{bc}	6.26	42.8^{cb}	5.01^{ab}	7.98^{b}	1.58^{bc}	37.90^{b}	6.31^{bc}
T_6	26.1^{b}	9.82	53.6^{b}	4.05^{a}	13.63^{b}	3.13^{a}	51.30^{b}	8.74^{bc}
Significance of difference	P≤0.01	ns	P≤0.01	P≤0.001	P≤0.05	P≤0.05	P≤0.001	P≤0.05
LSD	12.97	-	33.96	1.33	6.0	0.870	17.00	4.99

Figures with same letters are not significantly different

T_1 - No $ZnSO_4$ and $CuSO_4$ application (Control); T_2 - 50 g $CuSO_4$ and 100 g $ZnSO_4$ palm/y;
T_3 - 50 g $CuSO_4$ and 200 g $ZnSO_4$ palm/y; T_4 - 100 g $CuSO_4$ and 100 g $ZnSO_4$ palm/y;
T_5 - 100 g $CuSO_4$ and 200 g $ZnSO_4$ palm/y and T_6 - 200 g $CuSO_4$ and 400 g $ZnSO_4$ palm/y

Table 30. *Zn and Cu concentration in the 14th leaf of treatment plots before the 4th treatment application*

	Pottukulama site		Ratmalagara site	
No.	Cu mg/kg	Zn mg/kg	Cu mg/kg	Zn mg/kg
T_1	5.10	18.6	5.65	26.9
T_2	5.38	17.7	4.55	24.3
T_3	4.82	19.7	5.32	27.2
T_4	5.35	17.6	5.56	24.8
T_5	5.26	19.9	5.67	24.1
T_6	5.40	20.0	4.60	25.0
Level of significance	ns	ns	ns	ns
CV%	12%	14%	13%	15%

T_1 - No $ZnSO_4$ and $CuSO_4$ application (Control); T2 - 50 g $CuSO_4$ and 100 g $ZnSO_4$ palm/y; T3 - 50 g $CuSO_4$ and 200 g $ZnSO_4$ palm/y; T4 - 100 g $CuSO_4$ and 100 g $ZnSO_4$ palm/y; T_5 -100 g $CuSO_4$ and 200 g $ZnSO_4$ palm/y and T_6 - 200 g $CuSO_4$ and 400 g $ZnSO_4$ palm/y

As seen from Table 30, available Zn and Cu concentration in the soil of the manure circle has significantly changed at each level of treatment application of both sites. At the highest level of both Cu and Zn treatments, there was a highly significant increase in available Cu and Zn respectively in both the topsoil and the sub soil except the sub soil of Ratmalagara site. However, Cu and Zn concentrations in the 14th frond have not significantly increased in response to the increase in concentration of those elements in the soil (Table 31).

The critical levels of Zn and Cu in the 14th frond are considered as 30 mg/kg and 5 mg/kg respectively. The Zn concentration in the 14th frond remained below the critical level at both sites according to above criteria. The Cu concentration was above the critical level for many treatments except for T_3 treatment at Ratmalagara and for T_2 and T_4 treatments at Pottukulama.

The overall results indicate that palms at both sites have not responded to increase in Zn and Cu concentrations in the soil.

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

This experiment aims to quantify the removal of some nutrients from coconut palms growing in moderately suitable (S_4) and highly suitable (S_1) land classes.

The experiment, on the S_1 land suitability class (Madampe series soils) was commenced in September 1998 at the Bandirippuwa Estate and completed in 2000. The experiment on the land suitability class S_4 was commenced in 2001 in a field containing Boralu series soil in Bandirippuwa estate. Ten TxT palms, which were 20 years old, were randomly selected as replicates for the latter experiment.

The number and the weight of nuts and fronds and the weight of remaining flower parts of each palm were determined monthly. Chemical analysis of all plant parts is in progress.

Table 31 shows that the weight of nuts (54.9 kg/palm/y) and the weight of fronds (18.02 kg/palm/y) produced by palms on Boralu series soil was much lower than that by palms on Madampe series soil (116.7 kg/palm/y and 44.1 kg/palm/y respectively). However, the ratios of nut weight to total dry matter weight and the weight of fronds to total dry matter weight for Boralu series soil (0.65 and 0.22 respectively) were rather close to the corresponding ratios for Madampe series (0.63 and 0.24 respectively).

Table 31. *The dry weight of different components removed by a coconut palm - Boralu Series Soils at Bandirippuwa Estate (average of 10 palms)*

Month	No. of nuts/palm	Dry weight of nuts (kg/palm)	No. of fallen fronds/palm	Dry weight of fallen fronds (kg/palm)	Inflorescence, button nuts and immature nuts (kg/palm)	Total (kg/palm)
January	3.7	3.07	0.0	0.00	0.703	3.773
February	2.6	1.90	0.3	0.91	0.93	3.74
March	7.8	4.56	0.8	2.29	0.77	7.62
April	5.2	4.09	0.8	2.56	0.73	7.38
May	6.2	4.23	0.5	1.38	1.31	6.92
June	2.8	1.76	0.2	0.62	0.99	3.37
July	4.3	2.95	0.4	1.23	0.82	5.00
August	1.3	8.53	1.1	3.06	0.63	12.22
September	5.7	4.31	0.2	0.56	0.87	5.74
October	1.1	9.11	0.0	0.00	0.88	9.99
November	7.2	4.94	0.3	0.84	0.77	6.55
December	7.5	5.45	1.7	4.58	0.86	10.89
Total	55.4	54.9	6.3	18.02	10.27	83.193

L L W Somasiri, D M D I Wijebandara, D P Panditharatne, S Sabaratnam, W Gunasena and N M D Chandrasoma

Experiment 7.2.3 : Determination of MicroNutrients 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 located to represent some 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 32.

Table 32. *Sampling locations for micronutrients studies*

Soil Series	Location	Fertilizer practices		
Kalpitiya	Talawila, Palakuda, Kadayamatte, Daluwa, Setapola, Theheliya, Kurinchipitiya	Organic	Inorganic	No fertilizer
Weliketiya	Thoduwawa,Talawila, Kottantivu,Setapola, Pujapitiya, Marawila, Thoduwawa, Watawana, Ambakandawila, Udappuwa	Organic	Inorganic	No fertilizer
Pallama	Walpita, Gaspe	Organic	Inorganic	
Wilaththawa	Galmuruwa	Organic		
Katunayaka	Katunayaka, Kadirana		Inorganic	No fertilizer
Rathupasa	Marawila Mahawewa		Inorganic	No fertilizer

The leaf samples were analyzed for N, P, K, Mg, Fe, Mn and Cu. The mean value for each nutrient was calculated separately for sites having different fertilizer practices. The results are presented in Tables 33 and 34. There were no significant differences of nutrient concentrations among sites receiving different fertilizer application practices. Fe and Mn concentrations in the 14th frond were above the respective critical levels (> 40 ppm and > 60 ppm respectively).

However, the Cu concentration of the 14th frond was below the critical level (< 5 ppm) irrespective of the fertilizer practices (Table 34). As seen from Table 33, palms receiving organic manure or inorganic fertilizer were in the deficiency range for Mg (< 0.25%) and sufficiency range for K (1.2 - 1.5%) but those which never received fertilizer were in the sufficiency range for Mg and deficiency range for K (> 1.2%). Palms were in the sufficiency range for both N and P irrespective of fertilizer application practices. Zn and B analysis of the leaf samples are in progress. The results so far obtained revealed that Cu was probably limiting for the coconut palms but Fe and Mn was not limiting for the palms in the area surveyed.

Table 33. *N, P, K and Mg concentrations of different leaf ranks of palms receiving different fertilizer treatments - means of 23 sites*

Fertilizer practice	Leaf rank	N%	P%	K%	Mg%
Organic	1st	1.52 ± 0.18	0.142 ± 0.035	2.63 ± 0.32	0.18 ± 0.09
	6th	2.30 ± 0.32	0.148 ± 0.031	1.75 ± 0.48	0.20 ± 0.06
	14th	2.29 ± 0.25	0.141 ± 0.026	1.31 ± 0.29	0.22 ± 0.08
Inorganic	1st	1.57 ± 0.21	0.149 ± 0.023	2.69 ± 0.34	0.16 ± 0.03
	6th	2.28 ± 0.30	0.151 ± 0.021	1.73 ± 0.34	0.21 ± 0.08
	14th	2.24 ± 0.25	0.146 ± 0.022	1.32 ± 0.31	0.20 ± 0.04
No fertilizer	1st	1.61 ± 0.30	0.161 ± 0.018	1.94 ± 0.42	0.17 ± 0.05
	6th	2.4 ± 0.28	0.162 ± 0.140	1.16 ± 0.51	0.27 ± 0.13
	14th	2.26 ± 0.30	0.155 ± 0.012	0.90 ± 0.34	0.25 ± 0.11

Table 34. *Fe, Mn, Cu and Zn concentrations of different leaf ranks of palms receiving different fertilizer treatments - means of 23 sites*

Fertilizer practice	Leaf rank	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
Organic	1st	51.58 ± 25.94	40.26 ± 15.84	5.23 ± 1.23	41.02 ± 13.43
	6th	82.30 ± 34.56	82.98 ± 33.75	4.86 ± 0.86	52.22 ± 23.25
	14th	112.92 ± 67.26	149.97 ± 71.77	4.31 ± 0.81	47.14 ± 17.3
Inorganic	1st	50.35 ± 16.59	45.58 ± 31.68	5.17 ± 0.89	45.13 ± 21.39
	6th	87.34 ± 38.55	90.70 ± 58.01	4.87 ± 0.76	41.87 ± 21.14
	14th	119.50 ± 66.37	133.28 ± 75.01	4.15 ± 0.61	48.83 ± 24.22
Neglected	1st	70.79 ± 37.83	68.89 ± 47.54	6.52 ± 1.46	30.60 ± 12.01
	6th	125.25 ± 83.25	124.37 ± 87.84	5.45 ± 1.38	41.93 ± 17.96
	14th	241.29 ± 265.9	181.69 ± 140.7	4.40 ± 1.03	42.78 ± 15.47

L L W Somasiri, D M D I Wijebandara, G D George and K L Ranasinghe

PROJECT 8 : IMPROVEMENT OF POULTRY MANURE BY SEASONING

Experiment 8.0.1: Effect of seasoned poultry manure on its quality as a nutrient source for the coconut palm (1996)

This experiment, on a split-plot design with 3 replicates and 8 palms per plot was established at Pottukulama Research Station. The treatments in the main plots were layer/broiler litter and the treatments in the sub plots were litter seasoned for different periods.

Expt. No	Location	Agro-ecological region	Soil type	Land suitability class
8.0.1.1	Pottukulama	IL_3	Sandy loam (Welipelessa series)	S_2

The treatments are as follows.

Layer litter

1. Fresh
2. Stored for 1 month
3. Stored for 3 months

Broiler litter

1. Fresh
2. Stored for 1 month
3. Stored for 3 months

Control

No manure application

Each treatment was applied by two methods; namely, surface broadcasting and burying in trench.

The 6th manure application was completed in June. The leaf samples were collected from both sites prior to manure application and the samples were analyzed for major nutrients. Cumulative nut yield from May 1996 to April 2000 and average yield from May 2000 to April 2001 are given in Table 35. The differences in nut yields among the treatments were not significant in this year too. Recording of copra yields was disturbed in this year due to financial restriction.

Significant ($p \leq 0.05$) differences in N, K and Mg concentrations in leaf were observed among the treatments (Table 36). The P and K concentrations were mostly in the sufficiency range (0.11 - 0.13% and 1.2 - 1.5% respectively) but N and Mg concentration of several treatments were in the deficiency range (<1. 9% and <0.25% respectively).

Table 35. *Nut and copra yield of the experiment on poultry manure application; Pottukulama*

Treatments	Cumulative yield from May 1996 to April 2000		Yield from May 2000 to April 2001
	Nut Palm/y	Copra Kg/palm/y	Nut Palm/y
T_1 - Control (no manure) - surface	263	48.6	66
Control (no manure) - trench	269	46.6	56
T_2 - Fresh layer - surface	379	60.6	73
Fresh layer - trench	319	66.2	81
T_3 - Fresh broiler - surface	296	57.7	73
Fresh broiler - trench	306	62.3	67
T_4 - Layer stored for 1 m - surface	305	65.2	66
Layer stored for 1 m - trench	289	54.5	58
T_5- Broiler stored for 1 m- surface	290	60.2	68
Broiler stored for 1m- trench	289	55.4	64
T_6 - Layer stored for 3 m - surface	322	64.0	65
Layer stored for 3 m - trench	312	69.2	61
T_7- Broiler stored for 3m - surface	312	60.3	71
Broiler stored for 3m - trench	328	58.3	72
Significance	ns	ns	ns

Table 36. *N, P, K and Mg concentrations of the 14th frond of palm in the treatment plots*

Treatment	N%	P%	K%	Mg %
T_1 - Control (no manure) - surface	1.91	0.15	1.44	0.17
Control (no manure) - trench	1.63	0.16	1.23	0.18
T_2 - Fresh layer - surface	1.89	0.15	1.43	0.21
Fresh layer - trench	1.95	0.14	1.47	0.19
T_3 - Fresh broiler - surface	1.69	0.15	1.24	0.25
Fresh broiler - trench	1.89	0.15	1.42	0.20
T_4 - Layer stored for 1 m - surface	1.97	0.16	1.33	0.27
Layer stored for 1 m - trench	1.94	0.14	1.38	0.32
T_5- Broiler stored for 1 m- surface	1.94	0.16	1.28	0.19
Broiler stored for 1m- trench	1.49	0.15	1.35	0.25
T_6 - Layer stored for 3 m - surface	1.78	0.15	1.28	0.23
Layer stored for 3 m - trench	1.93	0.15	1.49	0.24
T_7- Broiler stored for 3m - surface	1.72	0.14	1.26	0.25
Broiler stored for 3m - trench	1.65	0.14	1.28	0.26
Significance ($p \leq 0.05$)	*	ns	*	*
LSD ($p \leq 0.05$)	0.15		0.063	0.076

This experiment was also carried out at a site in Badalgama from 1996 - 2000. Roots were counted at both sites from PRS and Badalgama sites in 1997 and 1998 respectively. Following are the main findings obtained by the root count.

(a) The poultry manure was harmful to both primary and secondary roots and this effect was greater with the broiler than with the layer poultry.

(b) Both layer and broiler poultry manures in fresh form were more harmful to coconut roots than those seasoned in heap for 1 month or 3 months.

(c) Trench application of poultry manure was much damaging to the roots than surface application.

The nut yields and the copra weights were significantly lower in the control plots than in the rest of the treatments ($P \leq 0.001$) after 5 years at both sites. However there was no significant difference in yield among treatment comprising poultry manure seasoned for different periods. Also, there was no significant difference in the leaf nutrient levels of the palms among the treatments.

Though the differences were not significant, the data showed that 1 month seasoned broiler poultry litter treatment resulted in 40% and 34% higher nut yield than that of fresh broiler poultry litter (at PRS and Badalgama sites) in 1999 and 2000 respectively. There was no significant difference in yield between 1 month and 3 months seasoned broiler poultry litter treatments.

The overall results indicated that at least 1 month seasoned poultry manure of either layer or broiler litter should be preferred for application to coconut palms to avoid root damages.

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PROJECT 9 : 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 applications 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 treatment plots, was established in 1999 at three locations as follows.

Expt. No	Locations	Agro-ecological region	Soil type	Land suitability class
9.0.2.1	Pottukulama Estate	IL_3	Sandy loam (Welipelessa series)	S_2

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

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 - APM (3 kg) in one half of the manure circle and kieserite (1 kg) in the other half of the manure circle
T_4 - APM (3 kg) in the entire manure circle and kieserite (1 kg) in the entire manure circle 6 months later
T_5 - The manure circle is divided into two portions; 0.8 m radius circle round the palm (Portion 1) and a 0.8 m wide strip, encircling the portion 1; Kieserite (1 kg) in portion 1 and APM (3 kg) in portion 2

The leaf samples, taken from the 14th frond in April were analyzed for K and Mg. Soil samples, taken in April from the depths of 0-20 cm and 20-40 cm were analyzed for exchangeable K and Mg. The results are given in Table 37.

Table 37. *K and Mg concentration (percent of dry matter) in the 14th frond and exchangeable K and Mg in the soil*

Treatment	Exch. K me/100 g		Exch. Mg me/100g		Treatments	Leaf K(%)	Leaf Mg(%)
	0-20 cm	20-40 cm	0-20 cm	20-40 cm			
T_1	0.26	0.19	0.67	0.34	T_1	1.55	0.19
T_2	0.13	0.12	0.73	0.34	T_2	1.59	0.26
T_{3a}	0.08	0.06	0.96	0.42	T_{3a}, T_{3b}	1.55	0.29
T_{3b}	0.31	0.28	0.55	0.27	T_4	1.52	0.28
T_4	0.18	0.19	0.94	0.45	T_{5a}, T_{5b}	1.55	0.26
T_{5a}	0.08	0.05	0.90	0.45			
T_{5b}	0.28	0.24	0.48	0.25			
Level of significance	P<0.01	P<0.01	ns	ns		ns	P<0.05
LSD	0.12	0.09	-	-		-	0.06

T_1 - APM only; T_2 - APM + kieserite; T_{3a} - half circle kieserite; T_{3b} - half circle APM; T_4 - APM + 6 month later kieserite; T_{5a} - inner circle kieserite; T_{5b} - outer circle APM

As seen from Table 37, exchangeable K concentrations of the top soil that received muriate of potash treatment in the half circle (T_{3b}), inner circle applications (T_{5b}) and full circle application without kieserite (T_1) were significantly higher than T_2 and T_4 which received kieserite treatments. There has been a decreasing effect on exchangeable K in the soil receiving kieserite. However there was no difference in leaf K concentration between treatments, which indicated that none of the kieserite application methods has affected the K uptake by the palm.

The difference in soil exchangeable Mg among treatments was not statistically significant. It implies that exchangeable Mg of the soil has not been significantly affected by the method of kieserite application. However, leaf Mg concentration in all the kieserite treatments have increased up to the sufficiency range (0.25 - 0.35%) while the leaf Mg concentration was below the sufficiency range in the control.

Table 38. *The nut yield of the palms in treatment plots*

Treatment	Yield in 2001 (nuts/ha/y)
T_1	16,600
T_2	15,700
T_{3a}, T_{3b}	15,900
T_4	15,600
T_{5a}, T_{5b}	15,100
Level of Significance	ns

As seen from Table 38, the nut yields were not significantly different between treatments.

L L W Somasiri, D Giritharan and B S V J Perera

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

The experiment commenced in March 2001 in a field containing Sudu series soils (S_4) at Bandirippuwa Estate. The Sudu series soils are described as imperfect to poorly drained deep sand. The experiment was designed with six treatments and 3 replicates. The treatment plot was a 1 1/2 m x 1 1/2 m square located at the centre of the square of a young coconut (3 years old) plantation. The treatments were as follows.

T_1 - No fertilizer application (control)
T_2 - 188 g of dolomite was applied and incorporated to the soil
T_3 - 150 g of urea was applied and incorporated to the soil
T_4 - 150 g of urea and 188 g of dolomite were applied separately and incorporated to the soil
T_5 - 150 g of urea and 188 g of dolomite were mixed together, applied and incorporated to the soil

Fertilizers were broadcasted on the soil and incorporate to the soil with a mammoty immediately.

After treatment application, soil samples up to 10 cm depth were taken daily from each plot. The raw samples were analyzed for pH, moisture, total N, ammonical nitrate and nitrate nitrogen. Temperature of the each plot was also measured daily.

The soil pH of all urea treatments increased by one unit with ten days and thereafter dropped gradually. There was no effect of dolomite on soil pH within the above period. The total N in soil increased by 23% in all urea treatments following the application and it gradually decreased near to the initial value in 14 days. The rate of decrease was not affected by the dolomite treatment.

NH_4-N content of the soil increased in T_3 and T_4 treatments by 10 times and in T_5 treatment by 13 times in 6 days. It shows that urea and dolomite mixtures is somewhat favorable for NH_4-N formation. No significant effect of dolomite was observed in NO_3-N content.

The results showed that the soil N in sandy soil treated with urea decreased within 22 days and rate of decrease was not significantly affected due to dolomite application with urea. Another site for this experiment in Boralu series (S4) soils were selected and the experiment will be commenced in July 2002.

D M D I Wijebandara, N A Tennakoon and S A B P Subasinghe

Experiment 9.0.4 : Preparation of a nutrient solution from coconut husk

The objective of the present study was to develop a non-destructive method for extraction of potassium and other nutrients from coconut husks before utilizing them for other purposes. The extraction would be used as a nutrient solution for coconut and other crops.

As a preliminary step, fresh husks and dried husks were soaked in water for one week and pressed using a rubber roller to extract nutrients. Analysis of extracts is in progress.

Also, water samples were collected from tanks where husks were soaked before processing for fiber and from wells close to those tanks. For this purpose, fibre mills were selected from Pannala, Welpalla, Udawela, Welipennagahamulla, Dummaladeniya, Bolawatta, Wennappuwa areas.

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

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 soils.

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.

Following are the treatments of the experiment.

T_1 - Control - no irrigation
T_2 - Husk buried round the palm (1/3 of the manure circle)
T_3 - Irrigation at 5 days intervals at 600 l per palm (10-30 kPa depletion range)
T_4 - Irrigation at 10 days intervals at 720 l per palm (10-100 kPa depletion range)
T_5 - Irrigation at 25 days intervals at 1080 l per palm (10-300 kPa depletion range)
T_6 - Irrigation at 40 days intervals at 1200 l per palm (10-1500 kPa depletion range)

Basal dosage: 3 kg Adult Palm Mixture and 1 kg of dolomite per palm annually

The irrigation treatments were meant to maintain different degrees of water stress in the palms by controlled irrigation and to determine the optimum irrigation rate that would nullify water stress. The nut yield data are given in Table 39.

Table 39. *Nut yield for each treatment*

Treatment	Yield (nuts/ha)	
	Cumulative yield from 1998 to 2000	2001
T_1	24324	9914
T_2	30070	11218
T_3	25200	10617
T_4	23726	9173
T_5	30798	14536
T_6	26495	10714
% CV	33	30
Significance of difference	ns	P<0.05

T_1 - control; T2 - 1/3 husk pits; T3 - 600 l at 5 days interval; T_4 - 720 l at 10 days interval; T5 - 1080 l at 25 days interval; T6 - 1200 l at 40 days interval

The analysis of variance showed that palms treated with 1080 l of water once in 25 days (T_5) showed a yield increase of 47% over the control treatment. In each irrigation treatment, palms were irrigated by 4 drippers, each delivering water at the rate of 30 l/h. In treatments T_3 and T_4, irrigation rates were 120 l and 72 l per day respectively compared to T_5 and T_6 of which the irrigation rates were 43.3 l and 30 l per day respectively. However only T_5 showed a significant yield increase ($p < 0.05$) over the control. The cumulative yield from 1998 to 2000 also showed that there was an increasing trend in yield in treatments T_2 and T_5. However the reasons for low yield in treatments T_3 and T_4, despite the high irrigation rate, is not obvious.

L.L.W.Somasiri, M T R D Perera and K R E M Fernando

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

Experiment 27.0.1: Evaluation of nutrient status of coconut growing soils (nutrient mapping 1992)

Soil samples from Kuliyapitiya series and Kurunegala series taken from a number of locations were analyzed for available Fe, Mn, Cu and Zn by extracting with 0.005 M DTPA-TEA solution. The data were analyzed statistically. The results are presented in Tables 40 and 41.

As seen from Table 40, available Fe, Mn and Cu were significantly higher in the soils regularly treated with fertilizer than that was never treated with fertilizer. There was no significant difference of available Fe and Cu between the two soil series. But there was a significant difference of available Mn and Zn between the two soil series (Table 41).

Leaf samples from the 14th frond of adult coconut palms grown on Boralu series and Pallama series soils were separately taken from 85 different locations. The samples were analyzed for N, P, K, Ca, Mg, Na, Fe, Mn, Cu and Zn and the mean values are presented in Table 42. Coconut palms on Boralu series soils were in the deficiency range with respect to K and Mg (% K < 1.2 and %Mg < 0.19 respectively) irrespective of fertilizer application practices. But the palms were in the sufficiency range with respect to other nutrients. The same situation was observed in case of Pallama series soils too.

Table 40. *Mean values of available Fe, Mn, Cu and Zn of Kuliyapitiya and Kurunegala series soils*

Fertilizer practices	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
With manure application	36.86	42.02	1.06	1.43
Without manure application	47.79	71.35	1.50	1.95
% Difference	29.65	69.8	41.5	26.67
Level of Significance	P<0.05	P<0.001	P<0.01	ns
LSD	9.53	12.81	0.28	
CV%	91.48	91.79	88.98	114.7

Table 41. *Mean values of leaf Mn and Zn concentration of Kuliyapitiya and Kurunegala series soils*

Soil series	Mn %	Zn %
Kuliyapitiya	230.16	32.91
Kurunegala	157.16	25.06
% difference with respect to Kurunegala series	46.45	31.32
Level of significance	P<0.01	P<0.05
LSD	49.51	6.45
CV%	51.12	44.52

Table 42. *Nutrient concentrations of the 14th leaf of coconut palms on Boralu series soils under different management conditions*

	N%	P%	K%	Mg%	Ca%	Na%	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
Boralu series - with manure application										
Mean	2.12	0.15	1.09	0.19	0.38	0.21	109.87	232.82	6.67	31.19
SD	0.24	0.02	0.29	0.06	0.11	0.09	31.26	102.57	1.29	13.44
N	63	83	83	83	83	82	80	80	80	80
Boralu series - without manure application										
Mean	2.01	0.15	0.92	0.21	0.35	0.26	122.56	222.42	6.88	31.29
SD	0.20	0.02	0.3	0.06	0.15	0.07	80.09	102.85	1.98	8.77
N	46	60	60	60	60	60	60	60	59	60
Pallama series - with manure application										
X	2.12	0.15	1.09	0.18	0.31	0.26	140.23	204.53	6.82	29.19
SD	0.26	0.05	0.34	0.05	0.13	0.12	66.43	109.48	1.28	10.34
N	54	79	79	79	79	79	67	67	67	67
Pallama series - without manure application										
X	2.00	0.17	1.00	0.18	0.30	0.28	176.51	180.67	6.71	32.96
SD	0.26	0.17	0.25	0.07	0.13	0.12	93.83	82.27	1.84	12.46
N	45	53	53	53	53	53	53	53	53	53

SD - Standard deviation
N - No of samples

L L W Somasiri, D M D I Wijebandara, U S S Perera, K P A Pathirana and A H Norman

PROJECT 30: STUDIES ON THE DECOMPOSITION PATTERN OF DIFFERENT ORGANIC MANURES

Experiment 30.0.1: Estimation of the decomposition rate of different sources of organic manure and nutrient availability to the coconut palm (1995)

This experiment, is a randomized complete block design with 3 replicates and 4 palms (45 years old) per plot, was established in 1996 at Mangala-eliya.

Expt. No	Location	Agro-ecological region	Soil type	Land suitability class
30.0.1.1	Mangala-eliya	DL_3	Deep loamy sand (Borupan series)	S_2

The treatments are annually applied as follows.

T_1 - Control (no fertilizer)
T_2 - Cattle manure (35 kg/palm/y)
T_3 - Goat manure (25 kg/palm/y)
T_4 - Layer poultry manure (30 kg/palm/y)
T_5 - Broiler poultry manure (30 kg/palm/y)
T_6 - Gliricidia (30 kg/palm/y)

Each treatment except T_1 is equivalent to 368 g of N.

Leaf samples were taken from the 14th frond of the treated palms in March 2001 and they were analyzed for N, P, K and Mg. The leaf nutrient concentrations were not significantly different between treatments. The leaf N and P concentrations were within their sufficiency ranges (1.9 -2.1% and 0.11-0.13% respectively) while K and Mg nutrient concentrations were just below their sufficiency ranges (1.2 -1.5% and 0.25 - 0.35% respectively) for all treatments.

The final soil sampling, before termination of the experiment, was taken in March 2001. Soil samples were taken from two depths viz., 0-20 cm and 20-40 cm. Soils were analyzed for physical and chemical parameters. The microbiological characteristics of the soil were presented in the Annual Report 2000.

Soil moisture content, bulk density and soil penetration (hardness) were determined as soil physical parameters. The results clearly showed that soil treated with organic manures contained higher moisture content and had lower bulk density and penetration than the control. The differences were statistically significant. Among the organic manure treatments, goat dung treated soils showed more favorable soill physical properties than other organic manures. Results are given in Table 43.

Table 43. *Physical parameters of the soil of the treatment plots*

Treatment	Moisture %	Bulk density g/cm^3	Soil penetration N/cm^{-2}
T_1	10.9	1.30	1.88
T_2	12.4	1.14	1.46
T_3	13.2	1.02	1.45
T_4	12.9	1.03	1.54
T_5	12.6	1.04	1.52
T_6	12.0	1.18	1.55
Level of significance	**	**	*
LSD ($p \leq 0.05$)	0.47	0.099	0.04

T_1 - No fertilizer, T_2 - Cow dung, T_3 - Goat dung, T_4 - Poultry litter (layer), T_5 - Poultry litter (broiler), T_6 - Gliricidia

Among the chemical parameters, available P, exchangeable K, Ca, and Mg and organic carbon showed significant differences between treatments. The results are given in Table 44.

Table 44. *Chemical parameters of the soil of 0-20 cm depth in the manure circle of the palms in the treatment plots*

Treatment	N (%)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	OC (%)
T_1	1.21	305	81	277	6.8	0.69
T_2	1.44	358	104	358	11.4	0.91
T_3	1.73	393	165	581	11.6	1.40
T_4	1.45	590	184	822	19.9	1.47
T_5	1.56	621	195	875	24.1	1.83
T_6	1.45	340	96	341	9.1	0.83
Significance	ns	**	**	**	**	**
LSD ($p \leq 0.05$)	-	157	107	261	14.3	0.91

Nut yields are given in Table 45. There were no significant yield differences between treatments during the whole period of the experiment. However yield of control plots (no fertilizer) was slightly lower than that of organic manure treatments. Among the organic manure treatments, goat dung treated palms showed the highest nut yield.

Table 45. *Nut yield in the experimental site at Mangala Eliya*

Treatment	Cumulative yield May 1996 to April 2000 Nuts/palm/year	Yield May 2000 to March 2001
T_1	201	53
T_2	239	68
T_3	234	64
T_4	227	67
T_5	233	67
T_6	251	56
Significance ($p \leq 0.05$)	ns	ns

This experiment was terminated in March 2001.

N A Tennakoon, S D H Bandara and M H Danasena

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

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

The experiment, on a randomized block design with 3 replicates and 6 palms (45 years old) per plot, was established in 1997 at the following locations.

Expt. No	Location	Agro-ecological region	Soil type	Land suitability class
30.1.1.1	Ratmalagara Estate	IL_1	Andigama series (moderately deep phase)	S_4
30.1.1.2	Pottukulama Estate	IL_1	Welipelessa series	S_2

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

The annual leaf sampling was done in April 2001 (one year after the 4th manure application) and the 5th manure application was completed in May 2001.

The nutrient concentrations in the 14th leaf of the plot palms at Ratmalagara site were in the sufficiency range with respect to N, P, K, Ca and Mg. Yield data of the Ratmalagara site are given in Table 46.

Table 46. *Yield data in the Ratmalagara site*

Treatment	April 1997 to March 2000 nuts/palm	April 2000 to March 2001 Nuts/palm	April 1997 to March 1999 Copra kg/palm
T_1 - Control	177	55	28.4
T_2 - APM + dolomite	201	68	39.8
T_3 - CD + MOP	222	76	36.0
T_4 - GD + MOP	228	74	27.2
T_5 - PM + MOP	243	73	36.2
T_6 - Gliricidia + SP + MOP + Dol	213	69	35.0
Level of Significance	ns	ns	ns

The experiment at Pottukulama was abandoned due to the damage to tender nuts in the plot palms done by monkeys and swills. However during the last four years, there was no significant difference in the yield between the control and the treatments at Pottukulama site. A new site has been selected in Wilattawa area (IL_2, Andigama soil series, S_4) for this experiment. Plot demarcation has already been completed and treatment application at this site and the experiment will be commenced next year.

N A Tennakoon, M A Wasanthi Mala and W Gunasena

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 major soils of the coconut growing area by bioassay techniques. A pot experiment was commenced using three different soil series (Boralu series, Wariyapola series and Kurunegala series) 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, were treated with the following treatments with 4 replicates in a Completely Randomized Block Design.

T_1	-	Control (no fertilizer)	
T_2	-	(-N)	1 g TSP, 0.2 g KCl, 0.1 g $MgSO_4.7H_2O$
T_3	-	(-P)	0.16 g $(NH_4)_2SO_4$, 0.2 g KCl, 0.1 g $MgSO_4.7H_2O$
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)	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 leaving 25 mm stubbles from the soil surface, at one-month intervals and fresh and dry weights were recorded monthly. The treatment

application was repeated at each cutting. Monthly harvesting will be continued until the vegetative growth of grass ceases. Cumulative dry matter yield of the grass as at December 2001 is given in Table 47.

Table 47. *Cumulative dry weight (in g) of vegetative parts of the Panicum*

Soil series	Treatments					
	T_1	T_2	T_3	T_4	T_5	T_6
Boralu	8.38	9.53	11.71	16.1	19.2	18.85
Wariyapola	8.85	16.45	18.43	22.6	22.21	19.10
Kurunegala	11.03	12.98	17.22	18.55	20.12	17.33

Chemical analysis of samples is in progress.

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 out whether there is soil degradation when forests are 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 as follows.

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	Galagedara	IM_3	Melsiripura series
Sawarangala forest	Sawarangala	IM_3	Melsiripura series

In case of Ambakelle and Weliketiya series soils, there was an increase of soil pH in the coconut-cultivated area compared to the area under forest. But in case of Andigama series soils, pH values were low in coconut cultivated area (Figure 1).

The electrical conductivity of all the soils in the experiment was higher under forest cover than under coconut. The effect was more prominently seen in Andigama series soils. Also, there was a decreasing trend in electrical conductivity with increasing depth for all three-soil series (Figure 2).

The organic matter content was higher in the forest soils than in the coconut-cultivated soils in case of all three-soil series. The decreasing trend of the organic matter with the soil depth was also seen in all three soils irrespective of the vegetation type. The highest organic matter content was present in Andigama series

soils under forest cover, which dropped by about 26% in the topsoil due to coconut cultivation.

However there was no significant difference in total N content between forest soil and the coconut cultivated soil. But in all three soils, the N concentration decreased with the depth (Figure 4).

The result showed that organic matter content of the soil dropped considerably when the natural vegetation was converted to coconut. This would cause degradation of soils with respect to chemical and physical properties.

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

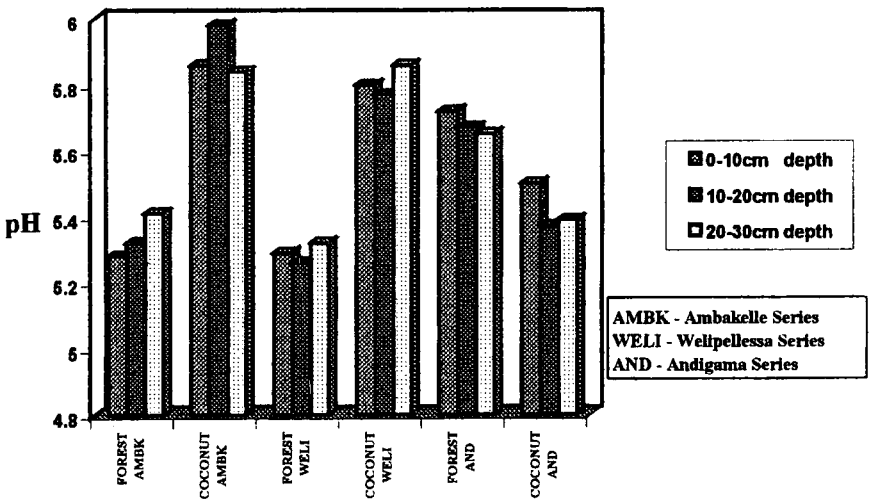

Figure 1: pH values of different soil series under forest cover and coconut

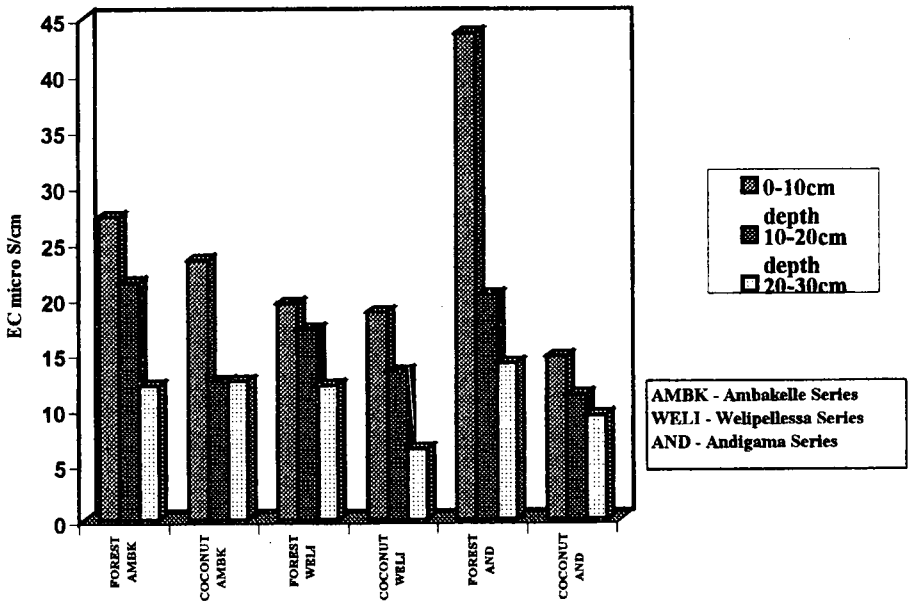

Figure 2: Electrical conductivity (EC) of different soil series under forest cover and coconut

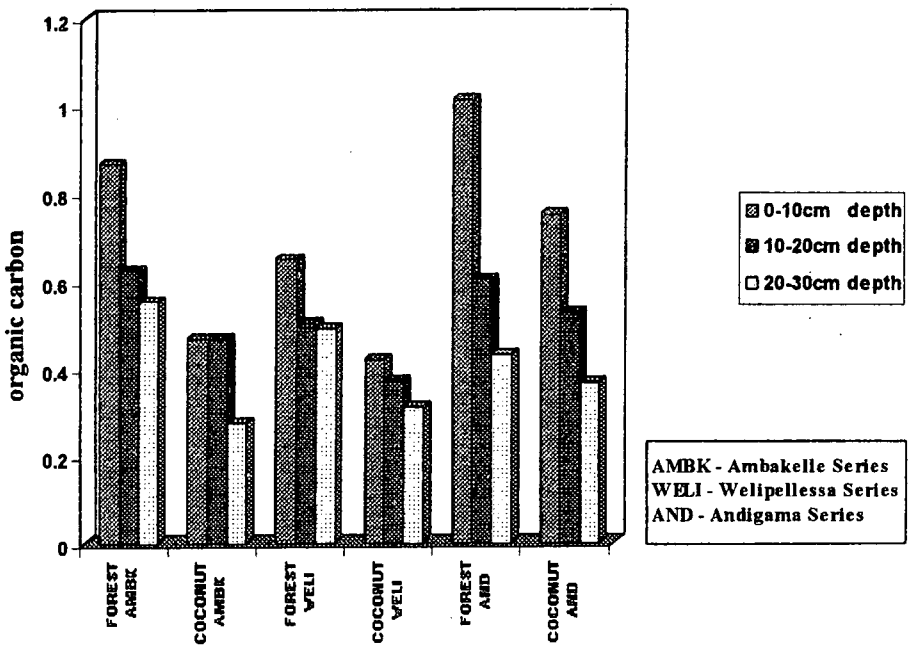

Figure 3: Organic carbon percentage of different soil series under forest cover and coconut

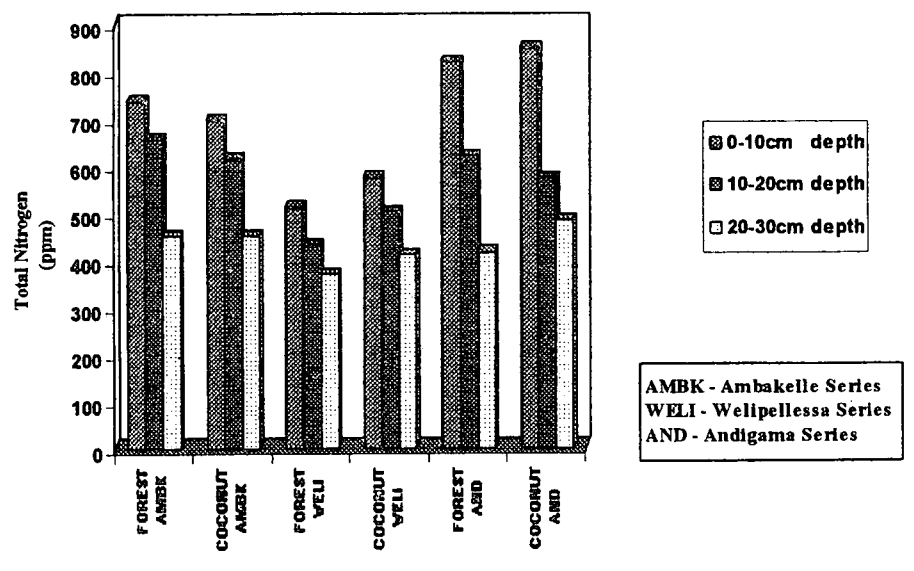

Figure 4: Total nitrogen content in different soil series forest cover and coconut

4. SERVICE FUNCTIONS

As service functions, the division provided Differential Fertilizer Recommendation (DFR) to 138 growers during the year. For quality testing 182 inorganic fertilizer samples, 13 organic manure samples and 200 coir dust samples were analyzed. In addition, soil survey for land use evaluation was carried out covering about 1000 ha. The Division staff also made 25 advisory visits on request of growers, participated as resource persons in one day training programs for growers and training courses National Institute of Plantation Management.

5. EXTENSION ACTIVITIES

Dr. N.A. Tennakoon, Dr. L.L.W. Somasiri and Mrs. D.M.D.I. Wijebandara participated as a resource person in one-day training program on Fertilizer Usage held in Coconut Research Institute.

Dr. L.L.W. Somasiri and Dr. N.A. Tennakoon participated as a resource person in a workshop on 'Coconut Cultivation with New Technology' held in Coconut Research Institute.

6. OTHER ACTIVITIES

Dr. L.L.W. Somasiri participated as a core team member in the Strategic Planning process of the CRI sponsored by the International Services for National Agricultural Research (ISNAR)

7. ACKNOWLEDGMENTS

I sincerely thank 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
Acting Head – I.R. Wickramananda, M Phil

1. GENERAL

During the year research program of the Division continued satisfactorily with more emphasis on developing and refining the management strategies for major pests and diseases. Particular attention was paid on the research project on control of coconut mite.

The experiment on the determination of optimum trap density for mass trapping of red weevil was completed. It was found that decrease in the trap density of the present recommendation (6 traps per ha) would result in decreasing weevil capture per unit area. Therefore, in order to trap a higher number of weevils the current recommendation will be continued. A new experiment was initiated to identify effective food sources that could replace toddy in the pheromone trap. Two food sources i.e. a yeast sucrose solution and nut water are being compared with toddy.

Experiments on the effect of releasing parasitoids, *Brachymeria nepahantidis* and *Eriborus trochanteratus* continued to show satisfactory results in controlling coconut caterpillar in different climatic areas. One release of each parasitoid at a rate of 1 to 500 of the pest reduced the population by over 95% within three months.

A study was conducted to find a suitable culture medium for laboratory rearing of coconut mite. Two agar-based media, wax coated perianths and tender leaf tissues were tested as the growing media. Tender leaf tissues in an arena placed in a Petri dish on a wax coated paper proved to be a suitable medium for rearing of coconut mite. Introducing new leaflets into the arena continuously could continue maintenance of the colony.

The study on the seasonal population pattern of *A. guerreronis* and predator *N. paspalivorus* was continued in three sites. The trend in fluctuations of the populations over time was similar to that of previous years. The population of *A. guerreronis* peaked in July - August, June - September and August - September in Kalpitiya, Madurankuliya and Vanathavillu respectively. The predator population also followed a similar trend in Vanathavillu. Life cycle, fecundity and feeding efficiency of *N. paspalivorus* is being investigated.

Efficacy of three neem based products i.e. ethanolic extract of neem seed kernels, 2% neem oil garlic soap mixture and Nomite plus, (a commercial formulation of neem oil and garlic) was compared under laboratory conditions using mite colonies on tender leaf tissues. Two percent neem oil and garlic mixture yielded the highest mortality of 88.1%. The mortality of neem seed kernel extract and Nomite plus were 66% and 55% respectively.

Population dynamics of the parasitic nematodes in the roots and soils of the Leaf Scorch Decline palms were studied throughout the year. A high incidence of parasitic nematodes in roots of affected palms was found in December while none was associated with the roots in other periods. Parasitic nematodes were present in the soil throughout the year.

Investigations on the *Ganoderma* root and bole rot were continued in the Southern Province. It was clear that the seedlings did not get infections up to three years after filling the vacancies created by the death of palms due to *Ganoderma*.

The investigation on the effect of oxytetracycline on Leaf Scorch Decline palms was continued. It was found that there was a positive effect of tetracycline injected to the trunks on the suppression of LSD symptoms. Investigations on the application of topsin, nemacur and oxytetracycline on rapid decline palms are also being continued.

Reports of coconut mite outbreaks were received from new areas such as Polonnaruwa, Anuradhapura, Jaffna and Kurunegala. Trunk injection of monocrotophos was recommended to selected areas with heavy infestations in Polonnaruwa and Kurunegala.

The staff continued to assist the growers and the Coconut Cultivation Board in managing the pests and diseases.

2. RESEARCH PROJECTS

PROJECT 15.1. STUDIES ON ACTIVITY PATTERNS OF LARVAL AND PUPAL PARASITOID SPECIES OF COCONUT CATERPILLAR (1995)

Experiment 15.1.19. Determination of the effectiveness of a single release of *Eriborus trochanteratus* and *Brachymeria nephantidis* in controlling coconut caterpillar in the field (2000)

The studies conducted in the previous year revealed that a single release of both *E. trochanteratus* and *B. nephantidis* could satisfactorily control coconut caterpillar in the field. However suitable pest: parasitoid ratios for each species have to be determined.

In this study, releases were made at two coconut caterpillar infested sites in Sevanagala and Kurunegala. In both sites *E. trochanteratus* and *B. nephantidis* were released at ratios of 500:1 and 75:1 of pest: parasitoid respectively. *B. nephantidis* was released at the start of the experiment while *E. trochanteratus* was released within a month after release of *B. nephantidis*. The results showed that a drastic reduction in the pest population occurred after the releases in both sites although the reduction at Sevanagala was higher than at Kurunegala (Table 1). Thereafter the pest population declined gradually and reached to very low numbers within 3 months. Parasitism rates of both species were high in the pest generation to which the release was made but declined in subsequent generations (Table 1). Coconut caterpillar could be controlled within 3 months by releasing *E. trochanteratus* and *B. nephantidis* once at the rates of 500:1 and 75:1 of pest: parasitoid respectively.

Table 1. *Percentage of the pest population in relation to the original population and percentage of parasitism by E. trochanteratus and B. nephantidis in relation to the pest population at the time of release at different intervals.*

Month	Sevanagala			Kurunegala		
	% Pest	% Parasitism		% Pest	% Parasitism	
		B. nephantidis	E. trochanteratus		B. nephantidis	E. trochanteratus
0	100	0	0	100	0.5	0.5
1	5.5	17.4	21.8	16.8	6.7	69.3
2	12.0	3.8	60.0	31.2	2.9	45.3
3	4.0	11.7	31.4	4.5	8.5	53.3

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

PROJECT 16.4 DEVELOPMENT OF A PHEROMONE TRAP FOR THE CONTROL OF BLACK BEETLE (1996)

Experiment 16.4.6 Effect of placing pheromone-baited traps in reducing damage of black beetle (2000)

The study commenced in an estate at Katunayake in the previous year showed that installation of 2 pheromone-baited traps per acre could reduce fresh bud damage in young coconut palms. Removing the traps in the latter part of that year resulted in an increase in damage and therefore traps were reinstalled. The fresh bud damage reduced from 8.4% to 1% within the year (Fig. 1). However, the trap catches were high throughout the period. The study clearly showed that pheromone-baited traps could keep bud damage at a minimum level, but the period of trapping may vary from location to location. The experiment was completed.

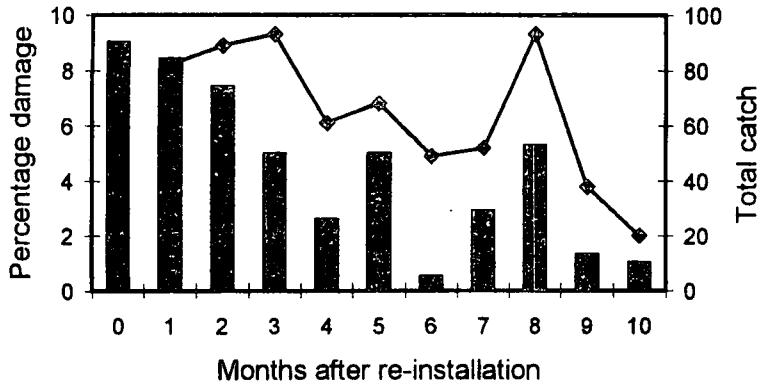

Fig. 1: Captures of *O. rhinoceros* (line) and percentage bud damage (bars) in the palms after re-installation of traps

L C P Fernando, D C L Hapuarachchi and N G Premasiri

Project 17: STUDIES ON THE CONTROL OF BOLE AND ROOT ROT DISEASE OF COCONUT (1993).

Experiment 17.1.3: Studies on the infection of coconut seedlings by *Ganoderma boninense* when filling vacancies in *Ganoderma* affected lands (1998).

Fifty vacancies that occurred due to the death of *Ganoderma* infected palms 1, 2, 3, 4 and 5 years before were filled with 10-month-old T x T coconut seedlings in Sitrakala estate. Ten seedlings were planted for each category. Root samples from 5 randomly selected seedlings from each category were plated on malt extract agar and Ganoderma semi selective medium aseptically. No infection was detected three years after planting. The experiment was completed.

H.T.R.Wijesekara, S.P.Manoj and N.G.Premasiri

PROJECT 18.1: INVESTIGATION OF BEEHONEY PRODUCTION IN DIFFERENT COCONUT BASED CROPPING SYSTEMS

Experiment 18.3: Assessment of the performance of honeybee colonies (1998)

The experiment commenced to determine whether nesting sites are a limitation for the existence of honeybees in coconut lands was continued. Thirty pots each at Walpita and Bandirippuwa and ten pots at Nalla were maintained. As in the previous year a predator bird attacked nine colonies at Walpita during February and March and therefore those colonies have been absconded during this period.

It was observed that in Walpita where many inter crops were available; the pots had a higher occupancy rate than in Nalla where only few inter crops are available (Fig. 2). Bees did not occupy pots at Bandirippuwa and therefore they were abandoned.

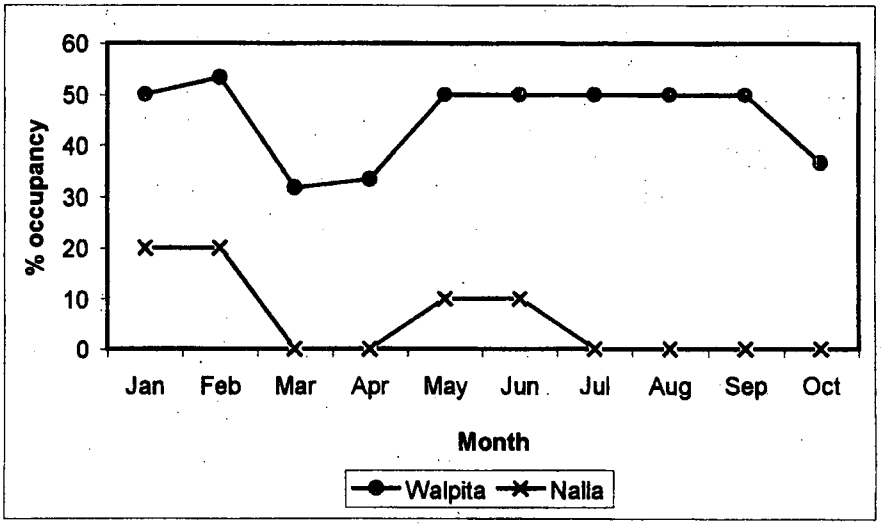

Fig. 2. The occupancy rate of pots by honeybees at Walpita, and Nalla during Jan-Oct, 2001

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

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

The improved electronic device to detect red weevil infested palms was tested in the field. Testing on limited number of infested palms was carried out. Placement of the sensor on 4 positions around the trunk at 1.5' distances revealed that the device could detect palms with initial symptoms, which may not be easily noticed by the growers. However, the device needs further improvement to detect presence of larvae from longer distances on the trunk. The experiment is in progress.

L.C.P. Fernando, K.F.G Perera & W.W.F.N. Fernando

Experiment 26.2: Determination of optimum trap density for mass trapping of red weevil (2000).

The two experiments at Badalgama and Dunkannawa were completed. At both sites, the number of weevils trapped per ha was highest at the density of 6 traps per ha. Decrease in the density to 4 and 2 traps per ha reduced the weevil capture in a density dependent manner (Figs. 3 & 4) Therefore in order to trap a higher number of weevils the number of traps in the present recommendation of 6 traps per ha is more appropriate. Further increase in the density may increase weevil capture further but it may not be economical for the growers.

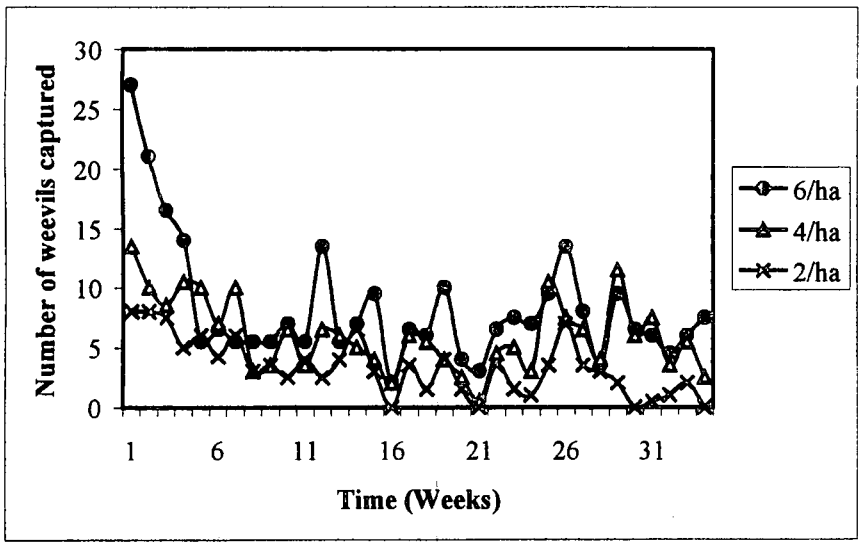

Fig.3: Number of weevils captured at different trap densities at Dunkannawa

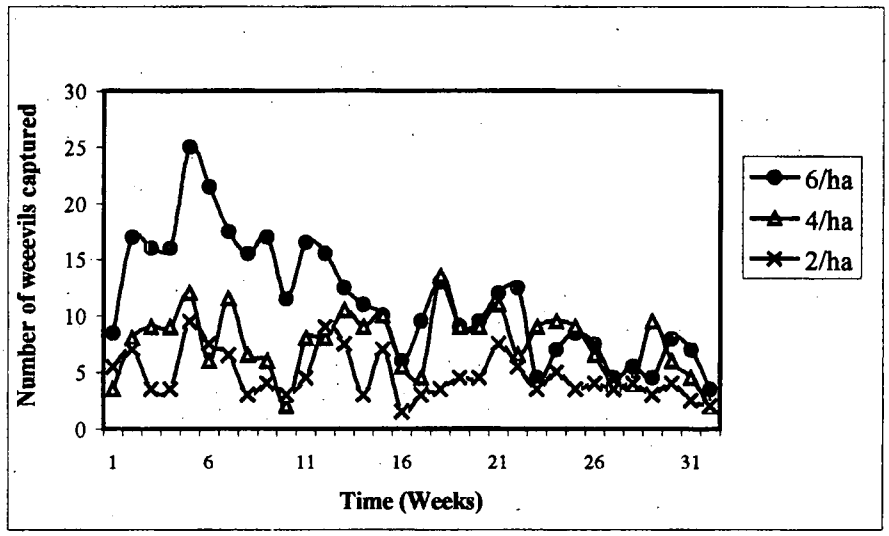

Fig. 4: Number of weevils captured at different trap densities at Badalgama

I.R.Wickramananda, K.F.G.Perera, W.W. F.N.Fernando & R.Wijetunga

Experiment 26.3: Identification of alternative food sources for toddy for the mass trapping of red weevil using pheromone-food baited trap (2001).

In the existing recommendation, it is recommended to incorporate either toddy or pieces of sugarcane into the pheromone trap to enhance the attraction of pheromone. But growers often complain that finding toddy and sugarcane is difficult as these materials are not readily available for most of the growers. Therefore this experiment was initiated with the objective of identifying easily available alternative food sources for toddy. Two materials i.e. 15% sucrose solution with 0.2% yeast and nut water from harvested nuts were compared with toddy. Results indicated that sugar-yeast solution attracts higher number of weevils. The experiment is in progress.

I.R.Wickramananda, K.F.G.Perera, W.W.F.N.Fernando & R.Wijetunga

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

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

The experiment commenced to determine the seasonal population fluctuation pattern of *A. guerreronis* and *N. paspalivorus* was continued in 6, 7 and 4 estates in Kalpitiya, Madurankuliya and Vanathavillu respectively. One young nut from each of five palms was sampled in each estate at monthly intervals. The number of coconut mites and predatory mites in each nut were recorded.

As in the previous year populations of both species of mites fluctuated over time in all experimental sites. In general, the peak population of coconut mite was observed between June and September. The peak populations in Kalpitiya, Madurankuliya and Vanathavillu were recorded between June-August, June-September and July-August respectively (Fig. 5). The study is in progress.

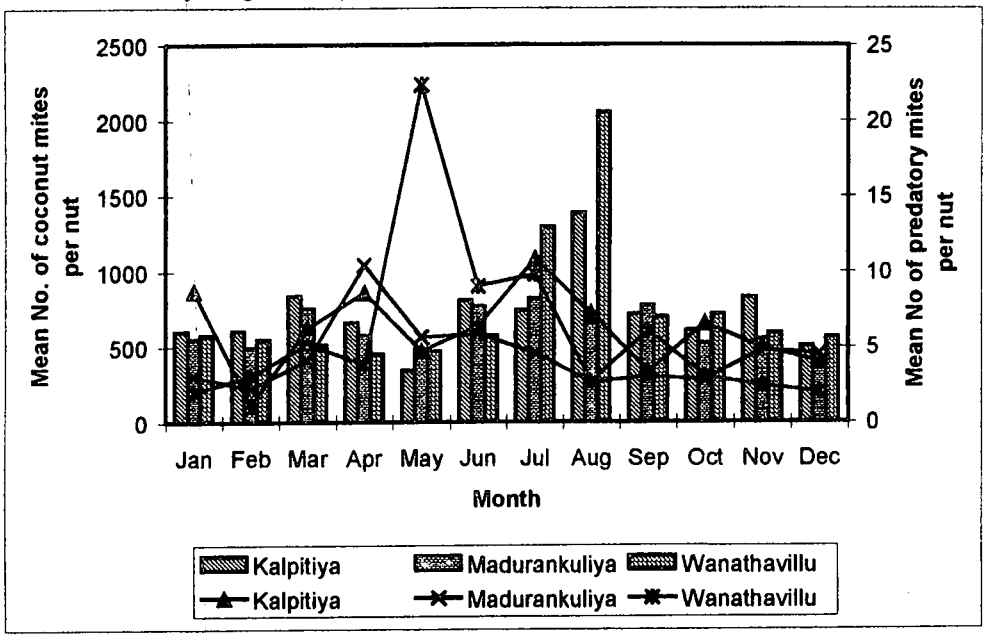

Fig. 5: Mean populations of coconut mite (columns) and predatory mite (lines) at Kalpitya, Madurankuliya and Vanathavillu

N S Aratchige, L C P Fernando, K A S Chandrasiri, P Manoj & S Fernando

Experiment 27. 17: Determination of feeding efficiency of *Neoseiulus paspalivorus* (2001)

An experiment was set up to determine the rate of *A. guerreronis* consumption by *N. paspalivorus* at $30^0 \pm 1^0$C and 80%±1 relative humidity. A day old eggs were collected from colonies maintained in the laboratory and were kept on waxed black papers in Petri dishes. Wet tissue paper stripes were placed along the margin of the black paper to avoid the escape of predatory and coconut mites and to provide drinking water. When the eggs were hatched, individual predatory mites were placed with a known number of coconut mites (*A. guerreronis*) and the number of coconut mites remained each day was counted to determine the number fed by *N. paspalivorus*. Experiment was continued until the all the predatory mites died. Average length of each stage of predatory mite was measured.

Total number of coconut mites fed by each individual of predatory mite, N. *papspalivorus* during its lifetime varied between 109-2101 with a mean of 627.5.

Time taken for the completion of egg, larval, protonymphal, deutonymphal and adult stages were measured as 1-2, 1-4, 1-3, 1-3 and 7-38 days respectively while 13-43 days were spent to complete the total life cycle.

D J Herath, N S Aratchige and S Fernando

Experiment 27.18: Identification of suitable alternative hosts for rearing of *N. paspalivorus* (2001)

A survey was conducted in Madurankuliya and Kalpitiya during April-May to find out a suitable alternative host for rearing of *N. paspalivorus*. Tender shoots and flowers of cashew (*Anacardium occidentale*), mango (*Mangifera indica*), *Moringa pterygosperma*, *Amaranthus paniculatus*, mulberry *(Morus alba)*, palmyrah *(Borassus flabellifer)*, gansooriya, *Typha* sp. and different grasses were collected separately and were observed under stereo microscope.

Eriophyid mites were found on tender leaves of mulberry (*Aceria mori)* and on palmyrah. It was observed that *N. paspalivorus* feeds on eriophyid mites found on mulberry. The experiment is in progress.

Another experiment was conducted to evaluate the suitability of eggs of *Dolichotranychus* sp., another mite species inhabiting under the perianth of coconut. An arena containing waxed black papers with moistened tissue paper stripes along the margins were used in this experiment. Pieces of coconut perianth infested by *Dolichotetranychus* sp. were used as the food source. According to the experiment *N. paspalivorus* feeds on eggs of *Dolichotetranychus* sp. Experiment is in progress to ascertain the possibility of using this as an alternative food source to rear predators.

D J Herath, N S Aratchige, S Fernando

Experiment 27.19: Effect of different food sources on development and reproduction of *N. paspalivorus* (2001)

A preliminary experiment was conducted to determine a pollen source as an alternative food source for *N. paspalivorus* because coconut mites alone could not be given due to difficulties in breeding them. Pollen were collected from grasses and other plants such as Ranawara (*Cassia auriculata*), Gansooriya, *Typha* sp., *Moringa* sp., *Zea mays*, *vigna sinensis*., *Crotolaria juncea,* paspalum grass and coconut. All these plants are commonly found in the area of infestation.

Pollen were collected from each of the species separately and stored in capped bottles until the experiment commenced. They were used to feed *N. paspaliorus* in arenas of waxed black papers and wet paper tissues around them. Each pollen type was replicated 3 times while each arena consisted of 5 eggs, which were one day old.

It was observed that except with *Z. mays* and *Vigna* sp., *N. paspalivorus* did not survive with any of the pollen sources tested. Even with *Z. mays* and *Vigna* sp., where *N. paspalivorus* developed up to adults in 2 and 3 plates respectively, they did not develop any eggs. This experiment was discontinued as the ground cover in the area was dried due to the heavy drought prevailed in the area and will be continued when the environmental conditions become favourable.

A preliminary experiment was conducted using an artificial diet containing egg albumin, bee honey and tap water. Five mated females were introduced into each arena and another group was given coconut mites for comparison. Each treatment was replicated 3 times. Three days after the commencement of the experiment females in arenas consisting of coconut mite only had laid eggs. Females had not laid eggs in arenas where the artificial diet was provided. There were no females with developing eggs in those arenas. The experiment will be continued with suitable modifications.

N S Aratchige, D J Herath, S Fernando

Experiment 27.20: Development of a method for laboratory rearing of coconut mite (2001)

In this experiment four different culture media i.e. extract of meristematic tissues in agar medium, cotyledon extracts in agar medium, wax coated perianths and tender leaf tissues in an arena placed in a Petri dish on a wax coated paper surrounded by pieces of moistened filter paper were evaluated for the suitability of rearing coconut mite. Inseminated female mites were introduced into different media and the populations were assessed over a period of 10 days. At the end of ten days significantly higher number of mites were present in the tender leaf tissues. Mean numbers of mites in each media i.e. agar-meristematic tissues, agar-cotyledon extract, wax coated perianths and tender leaf tissues were 4, 4, 14 and 301 respectively.

Hence it was clear that tender leaf tissues could be used to rear mites in the laboratory. The experiment was continued to find the possibility of maintaining a laboratory colony of *Aceria*. A new leaflet was introduced to the arena and kept in touch with the old leaflet after 8 days. Mites were allowed to shift slowly in to the new leaflet. The population in the new leaflet was assessed. The mite population continued to increase in the leaflets. By changing the leaflets every 8 days, the colony can be continuously maintained.

I.R.Wickramananda & P.H.P.R. de Silva

Experiment 27.21: Laboratory evaluation of Neem seed kernel extract, Nomite plus in comparison with 2% neem oil and garlic mixture (2001)

Ethanolic extract of neem seed kernels were prepared by extracting 20 g crushed seed kernels in 200 ml ethanol for 30 minutes. Defatting of the seed kernels with Petroleum ether for 2 h preceded this. The extract was rotary evaporated and re-dissolved in ethanol and diluted with water for the assay. Two per cent neem oil and garlic mixture and Nomite plus (a commercial preparation of neem oil and garlic obtained from India) at the rate of 4 ml per liter were the other two treatments. These three treatments were applied on to the mites on leaf tissues using a Potter spray tower. Water was sprayed as the control. Mortality of mites was observed over a period of 42 h.

Results showed that 2% neem oil and garlic mixture had the highest percentage mortality of 88%. Neem seed kernel extract and Nomite plus yielded 66% and 55% mortality respectively.

I.R.Wickramananda & P.H.P.R. de Silva

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

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

Three sites in Walpita (WL3), Arachchikattuwa (DL3) and Bandirippuwa estate (IL3) were selected to study the population fluctuations of the parasitic nematode *R. similis* in the roots and soil of LSD-affected palms over time. In each site 15 affected palms and 5 healthy palms were selected for sampling and 25 g of roots and 250 cm^2 of soil were collected from each palm at 3-monthly intervals. Parasitic nematodes were found in all the samples throughout the year. They were absent in the roots throughout the year except in December. In December mean number of 1.8, 6.2 and 1.6 parasitic nematodes were found in roots of LSD affected palms at Walpita, Arachchikattuwa and Bandirippuwa estate respectively. In healthy palms they were found at mean rate of 4.6, 0.6 and 0.4 at Walpita, Arachchikattuwa and Bandirippuwa estate respectively. However all the affected and healthy palms were not infected by *R. similis*. The observations suggest that presence of parasitic nematodes in the roots is seasonal. The experiment is in progress.

L C P Fernando and P H A P Siriwardena & W W F N Fernando

PROJECT B 26.5: STUDIES ON THE CONTROL OF LEAF ROT DISEASE OF COCONUT

Experiment B 26.5.2: Effect of large-scale application of systemic fungicides on the leaf rot disease of coconut (2001).

Preliminary experiments have indicated that drenching of systemic fungicide solutions are more convenient and effective in controlling leaf rot disease. Therefore, a large-scale application of Tebuconazole 25 EC (Folicur) at the rate of 4ml/l/palm at monthly intervals was commenced in Kanankaweva estate, Kotawila and Mallika estate, Sulthanagoda. It appeared that application of Folicur reduced the incidence of the disease. However, due to the prolonged drought in the area the disease incidence was subsided in untreated palms too and therefore the experiment was discontinued.

H.T.R.Wijesekara, S.P.Manoj and N.G.Premasiri

Experiment B 26.4: Evaluation of different chemicals as repellants for black beetle in coconut lands (2000)

Experimental site at Ratmalagara was abandoned due to high viral and fungal infestation in the artificial breeding grounds in the site.

Another experiment was commenced in Pallama Seed Garden, Magurankadawala to compare the efficacy of burnt engine oil, "Creobit", metasystox (3ml/100ml), carbofuran (15 g.) and "Calypso" (6ml/l). The experiment was designed as a randomized block design with 4 blocks for each treatment and each block having 9 seedlings. Each block was separated by at least three rows of seedlings. Fresh bud damage was recorded monthly in all seedlings including non-experimental seedlings. Treatments were repeated at three monthly intervals.

The results indicated that all chemicals are equally effective and the effect of burnt engine oil and Creobit lasts for more than three months. The experiment is in progress.

H T R Wijesekara, N S Aratchige, S P Manoj and N G Pemasiri

PROJECT 17: PREMATURE DECLINE OF PALMS

Experiment 17.6: Effect of oxytetracycline on the symptom expression in LSD affected palms (1999)

A new site at Pottukulama Research Station was selected for the treatment of plant formula of oxytetracycline. Thirty LSD palms in mild and moderate stage were selected and half of them were treated with 5 ml of oxytetracycline solution (1 g/ ml) and the rest with distilled water. Treatments were applied as trunk injection and repeated at four monthly intervals. Results showed that there was a reduction in percent scorched fronds in tetracycline treated palms than in untreated palms after two applications (Fig.6). The experiment is in progress.

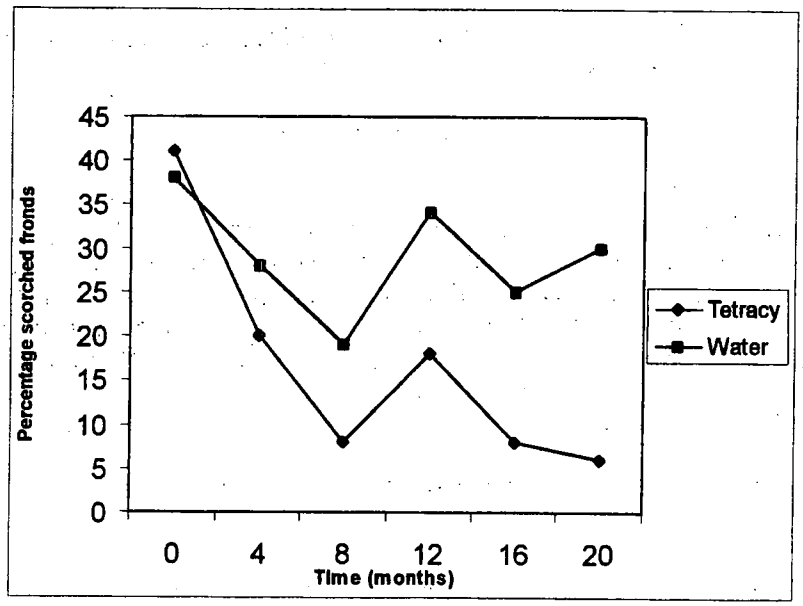

Fig. 6: Mean percentage of scorched fronds in LSD experimental palms in Pottukulama Research Station.

H T R Wijesekara, S P Manoj, N G Pemasiri

3. CROP PROTECTION SERVICES

Incidences of pest and diseases

One hundred and eighty five pest incidences were reported during the year. Appropriate control measures were recommended for the reported incidences.

Table 2. *Reported pest and disease incidences in different provinces during 2001.*

Pest	WP	NWP	SP	NCP	EP	UP	CP	NP	Total
Red weevil	3	67	6	4	1	2	2	-	85
Black beetle	2	8	1	1	-	-	-	-	12
Coconut caterpillar	5	16	5	-	9	1	-	-	36
Coconut scale	1	20	-	-	-	-	-	-	21
Mites	-	11	-	1	-	-	-	1	13
Minor pests	-	2	-	-	-	-	-	-	2
Diseases	-	10	-	-	-	-	-	-	10

Biological control and chemical control

a. Coconut caterpillar: Coconut caterpillar infestations were successfully controlled by timely surveillance, continuous monitoring and release of parasitoids. The number of parasitoids released are given in the Table 5 .
b. Weeds: The biological agent *Pareuchaetes pseudoinsulata* of the 'Podisingho maran' (*Chromalaena odorata*) was issued to the growers. A total of 29175 larvae were issued.

Table 3. *Release of parasitoids in different provinces for the control of coconut caterpillar.*

Parasitoid	Western	North Western	Southern	Eastern	Sabaragamuva	Total
Goniozus nephantidis	12250	17750	8250	7000	5000	50250
Bracon hebetor	7500	45500	4500	-	20000	77500
Eriborus trochanteratus	7500	25750	5550	4200	6225	49225
Brachymeria nephantidis	12100	43200	10800	12450	9800	88350

c. Synthesis and sale of red weevil pheromone:
Pheromone synthesis in the CRI laboratory continued and a total of 3874 pheromone vials were sold to growers and CCB regional offices.

d. Chemical control:
Trunk injection of Monocrotophos 60% was carried out in severe pest outbreaks. A total of 6050 palms were treated against coconut caterpillar (1550), coconut scale (750), nettle grub (1750) and coconut mite (2000).A total of 325 l of monocrotophos was sold to the growers to control red weevil and other pest out breaks.

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 Crop Protection Division during the year.

Training activities

One NDT student from Ampara Hardy Advanced Technical Institute completed his final year research project in the Division.

5. ACKNOWLEDGEMENTS

The staff of Crop Protection Division is gratefully acknowledged for their cooperation and assistance in research and other activities during the year. Sincere thanks are due to Head and staff of the Biometry Division for the assistance given in analysis of experimental data. The assistance provided by Head and research staff of Crop Protection Division in compiling this report is highly appreciated.

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 'Analysis of rainfall in coconut growing areas in Sri Lanka' funded by the National Science Foundation was continued during the year. 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.

   H P de Zoysa, J D J S Kularatna & S S Rajapakse

2. Co-ordinated the work in maintaining the Personal Management System in the Establishment Division.

   H P De Zoysa & S S Rajapakse

3. Assistance was provided for the installation of hardware and software. Co-ordinated activities of computers in the Institute.

   H P De Zoysa & 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, P Fernando, B Perera

5. Computerizing & 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

RESEARCH THRUST 20 : APPLICATION OF BIOMETRY IN COCONUT RESEARCH

Experiment 20.0.3: Calibration trial at Walpita Estate (Wet Zone) – (1984)

(a) The bimonthly recording of vegetative and yield characters were carried-out during the year. Variations in yield parameters and general status of yield pattern in the area between the six picks for the year 2001 are given in Table 1. The total number of bunches for the year showed a decrease of 2.4% over 2000, while number of nuts per palm, showed a decrease of 9.0%. The recorded yield was 12498 nuts/ha compared to 13710 in 2000. The copra yield per hectare was 2757 kg/ha as against 3013 kg/ha received in 2000. In general the year 2001 could be considered as a poor crop year with a yield decline of around 10% over the year 2000.

Table 1. *Yield components of palms at Walpita Estate in 2001 and 2000*
(Figures are Average from 100 palms)

Pick No.	Number of Bunches/Palm		Number of nuts/palm		Number of nuts/ha		Number of nuts/bunch		Weight of husked nut(g)		* Copra (kg/ha)	
	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000
1	2.0	2.0	12.8	10.9	2020	1719	6.3	5.4	707	728	457	400
2	1.9	1.8	13.7	14.6	2167	2301	7.2	8.0	733	707	508	520
3	2.2	1.8	19.9	18.5	3151	2928	9.0	10.3	680	642	686	601
4	2.3	2.4	14.1	17.9	2233	2835	6.2	7.6	656	668	469	606
5	1.9	2.1	9.8	12.6	1550	1985	5.1	6.0	654	711	324	452
6	1.7	2.2	8.7	12.3	1377	1942	5.0	5.7	712	698	313	434
Total	12.0	12.3	79.0	86.8	12498	13710			690	692	2757	3013

* **Copra Yield = husked nut weight x 0.32**

(b) Two monthly vs. monthly harvesting

Since the beginning of 1990, palms in the calibration trial were divided into two groups of 50 palms each and harvesting was carried out at two monthly intervals for one group and at monthly intervals for the other group. The number of nuts and copra yield per hectare for the two groups are shown in Table 2.

On an average 24.1% higher yields were shown for monthly harvesting when compared to two monthly harvesting over average yield during the period 1991-2000. In general the year 2001 showed a decline in yield compared to the year 2000. The monthly harvesting however showed no such decline when compared to the average yields of the period 1991-2000. Whereas, two monthly harvesting showed a decline of around 12% in yield for the year 2001 when compared to the average yields of the period 1991-2000. This has resulted monthly harvesting showing a yield difference of 41.6% when compared to two monthly harvesting during the year 2001. A reasonable conclusion is that when there is a yield decline, monthly harvesting tend to arrest this decline. The overall average yields for the period 1991 to 2001, showed 25.5% higher yields for monthly harvesting as compared to two monthly harvesting.

Table 2. *Number of nuts and copra yield at Walpita Estate*

Frequency of harvesting	Number of nuts per ha/year		Copra yield kg/ha/yr	
	1991 - 2000 Ave	2001	1993 - 2000 Ave	2001
Monthly (T_1)	14730	14708	3105	3304
Two monthly (T_2)	11873	10384	2278	2216
Difference	2857	4324	827	1088
% increase	24.1	41.6	36.3	49.1

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PROJECT 13: INFLUENCE OF HARVESTING PRACTICE ON NUT PRODUCTION (1997)

Experiment No. 13.0.1 Frequency of harvesting

Treatments: (a) Harvesting at 30 day intervals - T_1
(b) Harvesting at 60 day intervals - T_2
(c) Harvesting at 120 day intervals - T_3
(d) No harvesting, but collecting fallen nuts – T_4

Experimental Design: Randomized complete block design with 4 blocks and 6 palms per plot.

The experiment (20.0.3) at Walpita showed good promise for harvesting nuts at monthly intervals. As a result, further trials were established during the year 1997, two at Ratmalagara Estate (for high and medium yielding palms) and one at Poththukulama Research Station (for high yielding palms). The results obtained for the year 2001 are shown in Tables 3,4 and 5.

Table 3. *Yield components for medium yielding palms (2001) (Ratmalagara Estate)*

Frequency of harvesting (Intervals)	Bunches produced/6 palms		Nuts/6 palms Including fallen nuts		Fallen nuts/ 6 palms		% Fallen Nuts	
	2000	2001	2000	2001	2000	2001	2000	2001
30 days	74	78	412	393	12	12	2.9	3.1
60 days	64	70	352	382	42	68	11.9	17.8
120 days	49	65	307	349	100	145	32.6	41.5
No harvesting but collecting fallen nuts	53	70	303	369	303	369	100.0	100.0
Significance (P =)	0.01		ns					
CV (%)	4.8		10.8					
LSD	5.5							

Statistical analysis of data showed significant differences between the treatments only for bunches (p=0.01). Monthly harvesting at this site showed no significant yield improvement. The percentage fallen nuts for harvesting at 30 day intervals was a mere 3.1%. In general there appears to be higher percentage of fallen nuts.

Table 4 . *Yield components for High Yielding palms (2001) (Ratmalagara Estate)*

Frequency of harvesting (Intervals)	Bunches produced /6 palms		Nuts/ 6 palms Including fallen nuts		Fallen nuts 6 palms		% Fallen nuts	
	2000	2001	2000	2001	2000	2001	2000	2001
30 days	78	81	516	552	14	9	2.8	1.6
60 days	69	71	393	449	63	20	16.0	4.5
120 days	64	62	363	427	130	142	35.8	33.3
No harvesting but collecting fallen nuts	63	71	387	451	387	451	100.0	100.0
Significance (P=)	0.001		0.01					
CV(%)	5.0		8.9					
LSD	6		67					

Statistical analysis showed significantly higher number of bunches (p=0.001) and nuts (p=0.01) for harvesting at 30 day intervals as compared to harvesting at 60 day intervals. The respective percentages are 14.1 and 22.9.

Table 5. *Yield components for High Yielding Palms (2001) (Poththukulama Research Station)*

Frequency of harvesting (Intervals)	Bunches produced/6 palms		Nuts/6 palms Including fallen nuts		Fallen nuts/6 palms		% Fallen nuts	
	2000	2001	2000	2001	2000	2001	2000	2001
30 days	78	83	580	586	6	14	1.1	2.4
60 days	73	76	482	506	47	55	9.9	10.9
120 days	49	68	351	466	107	183	30.0	39.3
No harvesting but collecting fallen nuts	57	71	388	510	388	510	100.0	100.0
Significance (P=)	0.001		0.001					
CV (%)	8.0		11.5					
LSD	9.5		95.2					

The treatments showed similar results for number of nuts, as that was observed for the trial at Ratmalagara estate for high yielding palms. The percentage fallen nuts for monthly harvesting was as low as 1.1%.

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EXPERIMENT THRUST: 20.1 Application of Climatology in Coconut Research

Experiment No: 20.1.1 Analysis of rainfall in coconut growing areas in Sri Lanka
Details reported under outside funded projects

5. MISCELLANEOUS

a. Conversion factors used in the evaluation of National coconut production

* **National production function**

The national coconut production (Y) is estimated based on nut equivalent of various products as shown below. This estimation is done annually by the Coconut Development Authority.

Y = F_{DC}*(DC production in MT) + F_{CNO}*(oil production in MT) + F_{CPR}*(Copra exports in MT) + F_{CC}*(coconut cream exports in MT)+ F_{CMP}*(production of coconut milk power in MT) + (exports of fresh nuts) + (per capita consumption of fresh nuts)*(population)

Where F_{DC}, F_{CNO} , F_{CPR}, F_{CC} and F_{CMP} are the number of nuts required to produce 1 MT of desiccated coconut (DC), coconut oil (CNO), copra (CPR), coconut cream (CC), and coconut milk power (CMP) respectively.

In the recent past it is observed that the conversion rates (number of nuts) have changed rather inconsistently. This study explains the changes that had taken place in the recent past.

Conversion rates used

Table 6 shows how, the conversion rates have changed from time to time since 1996.

Table 6. *The number of nuts used to estimate nut production*

Year	No of nuts used to produce 1 MT of different products				
	F_{DC}	F_{CNO}	F_{CPR}	F_{CC}	F_{CMP}
Prior to 1996	6800	8000	4925	6800	6800
1996	8000	8000	4925	6800	6800
1997	8000	8000	4925	6800	6800
1998	8000	8000	4925	7325	6800
1999	8000	8800	5775	8000	8000
2000	8800	8800	5775	8000	8000

Publication by Coconut Development Authority

In order to get some idea about the conversion rates for DC, information was collected from DC mills run by co-operative and private DC mill owners to assess the number of nuts used to produce 1 MT of DC

Monthly data on desiccated coconut produced and the number of coconuts used were obtained on monthly basis from January 1994 to July 2001 from six co-operative mills and 11 private DC mills. Table 7 shows the average number of nuts utilized to make 1 MT of DC over different years.

Table 7. *The mean annual DC out-turn*

Year	Number of nuts utilized to produce 1 MT DC		
	co-operative mills	private mills	mean
1994	7221	7878	7550
1995	7633	8059	7846
1996	7550	8218	7884
1997	7667	8465	8066
1998	7353	8847	8100
1999	7198	7665	7432
2000	7118	7725	7421
2001*	7533	7785	7659

* Based on data up to July

The co-operative mills do not have the choice to select nuts as they have to purchase the nuts from their members. The private millers however use selected nuts. Thus one would expect lower figures for private DC millers.

These results suggest that when up-dating conversion factors from time to time it should be done based on an efficient sampling scheme to provide a reliable estimate for the National Production.

T S G Peiris and S Rajapakse

b. Field Survey

* **Use of Coconut Oil (CNO) by the householders**

During the recent past the rate of coconut oil used for cooking and other purposes by the householders had been varying due to many reasons such as importation of cheaper substitute oil for CNO and misconceptions on the use of CNO. This seriously affected the coconut oil producers, and as a result the local coconut industry too affected. In order to get first hand information on socio-economic and other inherent factors on the use of coconut oil, a householder survey was conducted during May and June 2001. The survey covered the districts of Colombo, Kurunegala and Nuwara-Eliya. The sample design was two-stage stratified random sampling with a size of 370.

The survey showed that 91.1% of householders in the sample used coconut oil for cooking purpose. The highest usage was in Nuwara Eliya (97.8%) and the lowest in Colombo (85.0%). The effect of various factors related to demographic, socio-economics and inherent variables were analysed separately using χ^2 statistics. Income, education level, and misconception about the CNO significantly influenced the use of CNO.

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6. EXTENSION ACTIVITIES

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

7. 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.

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7.1 Bandirippuwa Estate

(a) **Rainfall (Table 8)** All months of the year experienced rainfall. The total rainfall for the year was 1055.0 mm. This rainfall is lower than the average recorded for the period 91-2000 and over the year 2000. Upto August the rainfall for different months were drastically reduced as compared to 2000 except for the month of April.

(b) **Temperature (Table 8)** The monthly maximum temperature ranged from 30.7 (October) to 32.7^{0}C (March) while monthly minimum temperature ranged from 21.0(February) to 25.4 (May).

(c) **Sunshine (Table 8)** Sunshine hours ranged from 5.9 (January) to 9.3 hrs./day (March) The average for the year was 7.4 h./day The year showed increased sunshine hours compared to 2000. This is perhaps due to reduced number of rainy days observed during the year.

(d) **Evaporation.(Table 8)** The lowest and highest evaporation was recorded in November and the values were 3.2 to 4.6 mm respectively.

(e) **Relative Humidity (Table 8)** The average relative humidity in the morning fluctuated around 82% during the year. In the afternoon it varied around 76%.

(f) **Wind velocity (Table 8)** The wind velocity varied from 3.0 km/hr in April to 6.2 km/hr in August with a mean of 4.4 km/hr. In general there was high wind velocity over the year.

Table 8. *Meterorological Data (Bandirippuwa Estate)*

	Rainfall (mm)			Temperature (C^0)		Evaporation (mm)	Relative Humidity (%)		Sunshine (Hrs)	Wind Velocity (Km/h)
	2000	91-2000 Ave.	2001	Max.	Min.		a.m.	p.m.		
January	220.6	61.7	83.1	30.9	21.7	3.4	85	79	5.9	5.6
February	127.2	63.0	40.4	31.1	21.0	4.0	86	71	8.5	3.1
March	164.2	62.9	26.2	32.7	22.2	4.3	80	71	9.3	3.1
April	181.5	196.4	266.6	32.3	23.6	3.6	84	78	7.4	3.0
May	175.0	287.2	43.4	31.7	25.4	3.8	81	81	8.2	4.4
June	126.7	144.6	37.4	31.2	24.7	3.9	82	77	7.6	5.4
July	20.7	88.0	18.3	31.4	24.1	4.1	81	73	6.6	5.3
August	180.6	83.7	5.1	31.0	24.6	4.6	78	72	8.2	6.2
September	207.6	182.9	164.8	31.1	23.8	4.2	79	75	7.0	5.0
October	102.2	337.4	142.0	30.7	24.4	3.5	84	79	6.6	3.9
November	76.6	293.1	170.9	31.2	23.0	3.2	85	78	6.0	3.3
December	103.7	91.4	56.8	31.5	22.0	3.9	81	73	7.1	5.1
Total	1686.6	1892.3	1055.0	31.4	23.4	3.9	82	76	7.4	4.4

7.2 Ratmalagara Estate (Table 9)

All months during the year experienced rainfall accept March. The total rainfall was 1331.1 mm and the last six months experienced a rainfall of 60.0 % of the total. This pattern is rather unusual to the normal pattern of rainfall experienced over the past many years where the last six months period showing higher rainfall than the first six months period. This is similar to that experienced in 2000. It appears there is a reduction in rainfall during the first 6 months period. The total rainfall for the year was lower than that experienced in 2000 and also compared to previous 10 year period.

7.3 Isolated Seed Garden (Table 9)

All the months except March recorded rainfall, with July and August experiencing mere traces. The total rainfall for the year was 964.6 mm., as against 1498.6 mm., recorded in 2000.

7.4 Maduru Oya (Table 9)

Except May and August, rest of the months experienced rainfall. The total rainfall recorded for the year was 1782.0 mm., which is higher than the recorded rainfall of 1506.4 in 2000. Heavy rainfall was recorded for the months of January, April, October, November, and December. This accounts 1494.2 mm as compared to the total rainfall of 1782.0 observed for the year.

Table 9. *Rainfall (mm) at Ratmalagara, Isolated Seed Garden and Maduru oya*

	Ratmalagara Estate			Isolated Seed Garden			Maduru Oya	
	2000	91-00 Ave.	2001	2000	91-00 Ave.	2001	2000	2001
Jan.	89.7	41.0	116.2	102.5	52.2	90.5	205.3	307.2
Feb	231.5	54.2	46.1	79.5	49.5	63.2	235.3	127.2
Mar.	111.6	48.1	0.0	183.8	61.4	0.0	36.7	1.7
Apr.	243.1	192.1	231.6	255.8	170.2	262.6	34.1	242.4
May	157.5	228.7	112.8	164.6	186.4	15.8	19.6	0.0
Jun.	108.2	111.5	25.0	72.7	99.0	46.6	22.1	49.0
Jul.	10.3	52.3	5.7	1.4	46.4	2.9	27.9	59.0
Aug.	177.3	50.1	10.3	157.6	35.5	7.1	79.7	0.0
Sep.	157.1	139.9	187.6	164.8	113.3	134.3	57.6	50.9
Oct.	107.7	342.0	243.4	64.9	274.2	137.7	24.0	201.0
Nov.	120.0	353.5	301.9	65.8	291.2	171.2	506.5	280.5
Dec.	185.7	106.3	50.5	185.2	144.7	32.7	257.6	463.1
Total	1699.7	1719.7	1331.1	1498.6	1524.0	964.6	1506.4	1782.0

REPORT OF THE TISSUE CULTURE DIVISION
Head - L K Weerakoon, Ph D

1. GENERAL

During the year, greater attention was given to biochemical and molecular studies in order to understand the fundamental aspects of plant regeneration through somatic embryogenesis.

Twenty-eight tissue-cultured coconut plants were planted at Bandirippuwa Estate, Daisy Valley Estate and Lenawa Estate to evaluate their performance in the field. The growth of the tissue-cultured plants established previously at Bandirippuwa Estate was found to be satisfactory. Twenty more tissue-cultured plants were fully acclimatized and ready for field planting.

Several plant regeneration protocols were tested for *in vitro* somatic embryogenesis from plumule-derived callus. Application of 5.0-µM ABA for 5 weeks resulted in consistent plant regeneration at a low frequency (4.4 %). The effect of high agar-induced moisture stress, different cytokinins and $AgNO_3$ (at different concentrations) in combination with ABA on somatic embryogenesis and plant regeneration was assessed. Application of water stress induced by high agar concentration significantly increased the frequency of somatic embryogenesis (62.1 %) and plant regeneration (9.0 %). The effect of cytokinins varied with the type and concentration whereas the effect of Ag NO_3 depended on the concentration. Application of cytokinin in combination with ABA showed a tendency for multiple shoot regeneration.

Comparative biochemical studies of zygotic embryos and *in vitro*-cultured tissues were undertaken with the objective of identifying possible biochemical markers of embryogenesis. The changes in proline and total sugar content in developing zygotic embryos and *in vitro*-cultured tissues showed a similar trend. Cultures with embryogenic structures contained lower levels of proline and total sugar whereas the cultures with non-embryogenic structures contained significantly higher levels of proline and total sugar. The variation in the content of proline within a particular type of tissue was very high while the variation was less for total sugar content. Determination of endogenous ABA level in *in vitro*-cultured tissues at different stages of development did not reveal any specific pattern. Analysis of protein profiles in zygotic and somatic embryos revealed the occurrence of similar polypeptides in the two types of embryos. However, no embryogenic-specific proteins were detected.

Preliminary studies on developing a molecular marker of embryogenesis were conducted. Expression of Retinoblastoma (Rb) gene (a cell cycle controlling gene) in embryogenic and non-embryogenic callus was studied using ddRT-PCR technique. The results revealed that expression of Rb gene in non-embryogenic callus was higher than that of embryogenic callus indicating the possibility of using Rb gene as a marker to screen embryogenic callus.

Accumulation of certain compounds in inflorescence tissues at different developmental stages was studied in order to find any correlation between the

biochemical characteristics of the explant and its morphogenetic potential. The content of proline, total sugar and starch were determined in a series of inflorescences (from –1 to –13, taking the youngest open inflorescence as 0). A decline in the content of proline and starch was observed with increasing maturity of infloresence. In regard to content of total sugar, a gradual increase was observed from –13 to –7 stages and a declining trend was observed thereafter.

Preliminary investigations on pollen and ovule culture were initiated in order to develop technology for the production of double haploids. The developmental stage of pollen is a critical factor in androgenesis. As it is convenient to resort to an external marker for collecting anthers at the correct developmental stage, a study was undertaken to identify any correlation between the age of the spadix in terms of Weeks Before Splitting (WBS) and stage of pollen development in Sri Lanka Tall coconut under local environmental conditions. The results revealed that the late uninucleate stage (which is reported as the most suitable stage for androgenesis) could be obtained from 3 WBS spadices whereas it is shortened by one week during severe drought conditions.

A total of 274 dikiri embryos were cultured using the COGENT upgraded embryo culture protocol (developed by combining the good qualities of 4 different embryo culture protocols). With the new protocol, the germination rate of dikiri embryos was observed to be high (85.2%) and the growth of *in vitro*-raised plants was found to be satisfactory.

Investigations on cryopreservation of mature zygotic embryos of coconut were initiated. Three protocols were tested with different methods of desiccation. The best recovery rate (60 %) of embryos was achieved by the combined effect of 10 h desiccation of embryos by silica gel followed by pretreatment in 600 g l^{-1} glucose and 15 % glycerol for 15 h.

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 project (funded by the DFID and IPGRI) was undertaken with the aim of mass propagating dikiri coconut using the COGENT upgraded coconut embryo culture protocol (developed by combining the good qualities of 4 different embryo culture protocols).

A total of 274 dikiri embryos were cultured using the above protocol. The germination percentage of embryos was observed to be high (85.2 %). Thirty-one plants have already been transferred to soil. These plants were ready for potting within a period of 5-6 months of culture and their growth at the time of transplanting was found to be satisfactory.

During the year, 27 embryo-cultured dikiri plants were issued to 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)

Forty coconut plants (of the accessions Sri Lanka Green Dwarf, Sri Lanka Yellow Dwarf, Sri Lanka Green Dwarf X Sri Lanka Tall, Sri Lanka Tall (Moorock) and Sri Lanka Tall X San Ramon) that survived the stress conditions caused by different levels of PEG were planted at Lenawa Estate for the evaluation of their performance under field conditions. The growth parameters of the palms (that survived the stress conditions caused by different concentrations of PEG), which had already been established at Lenawa Estate, were measured.

L K Weerakoon, E S Santha and K P I E Ambagala

Experiment 18.1.6: Cryopreservation of coconut embryos (2001)

Cryopreservation is the only viable option for the long-term conservation of coconut germplasm. Thus a study was undertaken with a view to develop an efficient protocol for cryopreservation of mature zygotic embryos of coconut.

The cryopreservation methods employed in the study were based on pregrowth-desiccation. Three experiments were conducted with different methods of desiccation and preculture. In Experiment 1, a published protocol was used where the embryos were desiccated in the air current of a laminar flow cabinet for 4 h. This was followed by a cryoprotective treatment with 600 g l^{-1} glucose and 15% glycerol for 15 h. The recovery rate of frozen embryos was reduced to 42. 9 % when compared to 100 % recovery of the untreated control. The growth rate of the frozen embryos was also slow and germination was delayed by 2-3 months.

In Experiment 2, the embryos were precultured in a sucrose solution (0.5 and 1. 0 M) for 96 and 120 h prior to desiccation by silica gel for 5, 10 and 15 h. Total inhibition of germination in frozen as well as many of the control embryos was observed when precultured in high concentration of sucrose (1.0 M) indicating the damaging effects of high sucrose. The highest recovery rate (40 %) was observed in embryos precultured in low concentration of sucrose (0.5 M) for 120 h followed by 15 h exposure to silica gel. These results indicated that preculture of embryos in low concentration of sucrose for longer durations combined with longer durations of desiccation results in higher recovery rates.

In Experiment 3, the embryos were desiccated by exposure to silica gel for 8.,10 and 12 h. This was followed by a cryoprotective treatment with 600 g l^{-1} glucose and 15% glycerol for 10 and 15 h. Better recovery of embryos was observed in Experiment 3, when compared to Experiments 1 and 2. Thus the procedure followed in Experiment 3 was shown to be more effective for cryopreservation of mature embryos when compared to the other 2 procedures. The best treatment in

Experiment 3 was 10 h desiccation followed by 15 h cryoprotective treatment, which gave rise to the highest recovery rate (60 %) in frozen embryos (Table 1).

The results indicated that slow desiccation of embryos by silica gel for long durations was more effective than rapid desiccation in an air current in a laminar flow cabinet. The degree of desiccation was also shown to be critical for successful post-thaw recovery of embryos. The best embryo recovery (60 %) was observed when embryos had lost 63.7 % (Fig. 1) of their water content. The composition and concentration of the preculture medium as well as the duration of preculture were also found to be critical factors, which determine the rate of success in cryopreservation. Further refinements to the procedures developed in this study could lead to a reliable and efficient cryopreservation protocol, which could be applied for long-term storage of coconut germplasm.

Table 1. *Percentage of germination (after 8 weeks culture) of controls (LN-) and frozen (LN+) embryos of coconut*

Duration of exposure to silica gel	8 h		10 h		12 h	
Duration of exposure to pregrowth medium	10 h	15 h	10 h	15 h	10 h	15 h
Percentage of germination						
LN-	40	50	50	100	100	50
LN+	0	40	0	60	40	40

- Percentage of germination in untreated control = 100 %

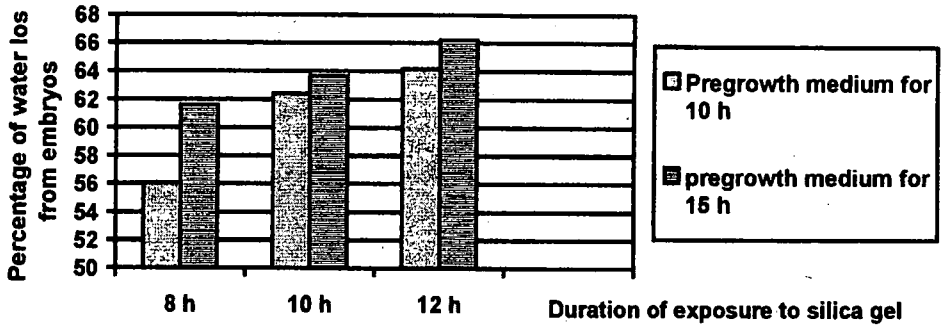

Figure 1: *Mean percentage of water loss from embryos after pretreatment and desiccation by silica gel*

L K Weerakoon and J A S S C Jayasinghe

18.2. Studies on clonal propagation of coconut

Experiment 18. 2. 1. *In vitro* culture of immature zygotic embryos of coconut

Previous studies indicated the beneficial effects of $AgNO_3$ (at 5-10 µM) and high agar (2 %)- induced water stress (in combination with 5 µM ABA) on somatic embryogenesis and plant regeneration. Thus the combined effect of the above factors on somatic embryogenesis and plant regeneration was tested. The results revealed that the combination of 5 µM ABA together with 10 µM $AgNO_3$ and 2 % agar improved the frequency of plant regeneration.

The effect of AVG (an ethylene inhibitor) on somatic embryogenesis was tested. AVG was incorporated into somatic embryo induction medium and regeneration medium at 3 levels (1, 2 and 3 µM). The preliminary results indicated that AVG had a positive effect on somatic embryo formation and shoot regeneration at the level of 3 µM.

The effect of the polyamine, putrescine on induction of somatic embryos in immature embryo-derived callus is being investigated. The medium 72 was selected as the basal medium and 3 levels of putrescine (1.0, 5.0 and 7.5 µM) in combination with ABA (5 µM) are being tested.

Fifteen 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 1999 and 2000 was found to be satisfactory.

L K Weerakoon, S C Fernando, E S Santha, C K A Gamage and K P I E Ambagala

Experiment 18. 2. 4. Culture of floral meristem explants (1995)

At present, the suitable developmental stage for *in vitro* culture is assessed by the length of the inflorescence and immature inflorescence with an external spathe length of about 10 cm (which usually corresponds to -5 to -9 stages, taking the youngest open inflorescence as 0) are used for *in vitro* culture. However, better criteria are needed to assess the physiological maturity of the explants as the length of inflorescence varies widely from palm to palm.

Identification of a suitable marker for selecting the most responsive developmental stage of immature inflorescence for *in vitro* culture would lead to consistent callus production at a high frequency. Thus accumulation of certain compounds in inflorescence tissue at different developmental stages was studied in order to find any correlation between the biochemical characteristics of the explant and its morphogenetic potential. The content of proline, total sugar and starch were determined in a series of inflorescence (from –1 to –13 stages). A decline in the content of proline (Fig. 2) and starch (Fig. 3) was observed with increasing maturity of inflorescence. In regard to content of total sugar, a gradual increase was observed from –13 to –7 stages and a declining trend was observed thereafter (Fig. 4). Further studies in this direction might lead to the identification of a suitable biochemical marker to assess the morphogenetic potential of inflorescence tissues.

Attempts were made to induce callusing in explants obtained from very tender inflorescence (-11 to –14 stages). The results revealed that callusing in these explants was poor and only 14 % of the explants from -12 stage produced callus. Moreover, a high incidence of browning was observed in the cultures.

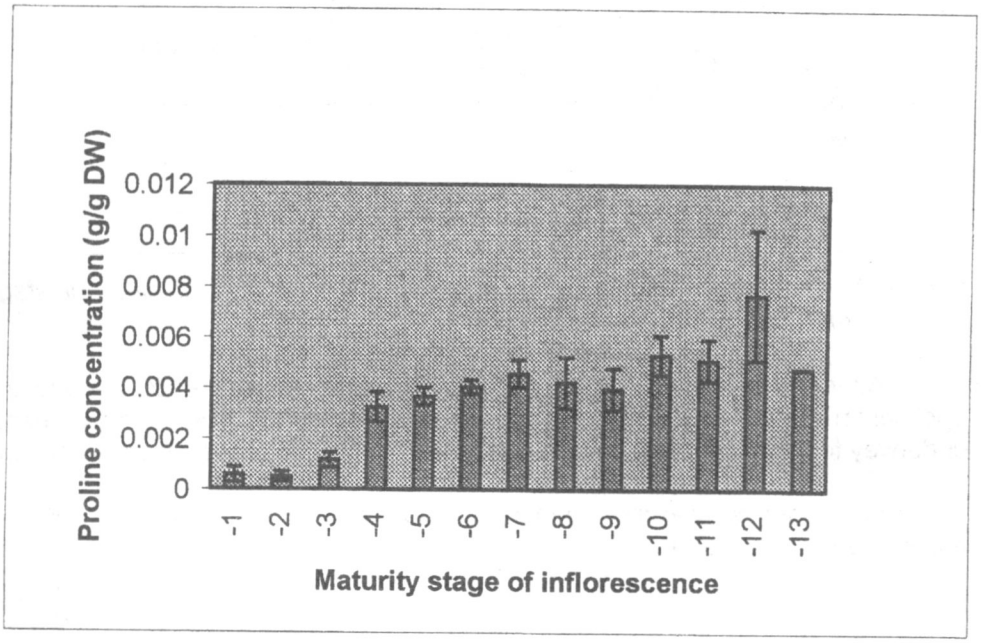

Figure 2.: *Variation in proline content in inflorescence at different stages of maturity*

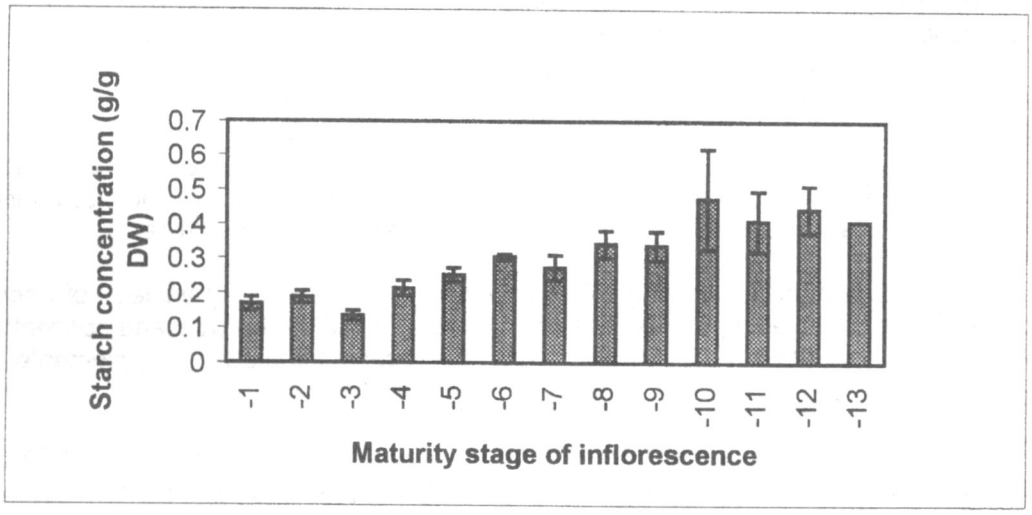

Figure 3. *Variation in starch content in inflorescence at different stages of maturity*

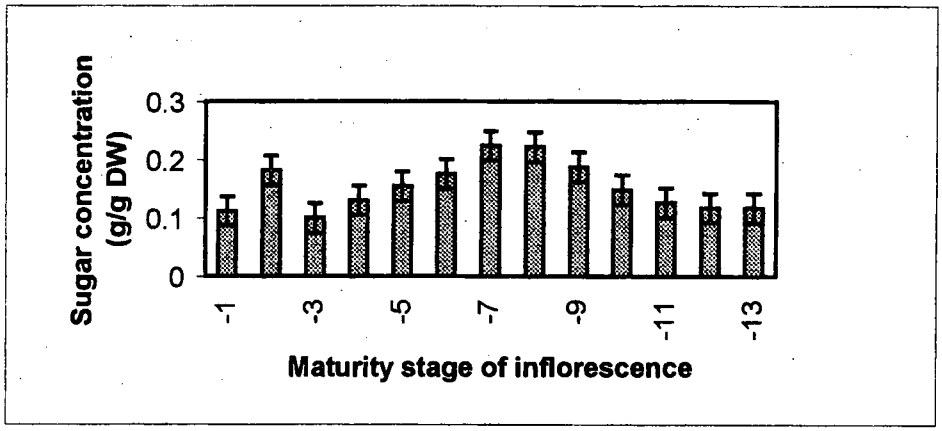

Figure 4. *Variation in total sugar content in inflorescences at different stages of maturity*

Attempts to induce organogenesis in immature inflorescence explants by application of high levels of cytokinin were unsuccessful. Further experiments are underway to define suitable culture conditions for organogenesis from floral explants.

One plant derived from immature inflorescence callus was fully acclimatized and ready for field planting.

H D D Bandupriya and L K Weerakoon

Experiment 18. 2. 5. Culture of plumule explants (1997)

Generally, somatic embryogenesis in plumule-derived callus is achieved by application of 5 μM ABA. However, the frequencies of somatic embryogenesis and plant regeneration are still low. Therefore, the effect of several factors (high agar concentration (2 %)-induced water stress, cytokinins (BAP, 2iP, Kinetin and TDZ) and $AgNO_3$ [1-10 μM]) on somatic embryogenesis and plant regeneration was studied as an attempt to improve the regeneration protocol.

As shown in Table 2, the stress treatment significantly increased the frequencies of somatic embryogenesis and plant regeneration) when compared to the ABA treatment without stress conditions (0.8 % agar for five weeks).

Furthermore, the results revealed that the frequencies of somatic embryogenesis and plant regeneration were affected by the type and concentration of cytokinin (Tables 3 and 4). Based on the results, the medium supplemented with 5 μM ABA and 5 μM 2iP was selected for further experiments.

It was observed that application of cytokinins in combination with ABA tends to induce multiple shoot formation. However, shoots regenerated in media containing higher levels (10-15 μM) of cytokinin showed a poor growth.

Table 2. *The effect of high agar concentration-induced water stress on somatic embryogenesis and plant regeneration*

Treatment	Somatic embryogenesis (%)	Plant regeneration (%)
ABA (5 μM) + 0.8 % (w/v) agar for five weeks	28.1	4.4
ABA (5 μM) + 2 % (w/v) agar for two weeks followed by ABA (5 μM) + 0.8 % (w/v) agar for three weeks	62.1	9.0
Significance	p= 0.001	p= 0.01
CV (%)	87.4	31.8
LSD	1.5	0.3

Data represents means of the experiment repeated seven times with 30 replicates per treatment.

Table 3: The effect of different cytokinins at different levels on somatic embryogenesis frequency *(%)*

Cytokinin	Concentration (μM)		
	5	10	15
BAP	32.3	15.8	10.6
2iP	40.6	33.7	22.0
Kinetin	23.5	31.6	42.7
TDZ	16.2	39.7	39.4
Significance	P= 0.01		
CV (%)	58.9		
LSD	4.6		

Data represents means of the experiment repeated three times with 30 replicates per treatment.

Table 4: *The effect of different cytokinins at different levels on plant regeneration frequency (%)*

Cytokinin type	Concentration (μM)		
	5	10	15
BAP	6.6	1.9	0.7
2iP	6.6	1.1	0.0
Kinetin	0.0	4.3	1.1
TDZ	0.0	4.5	5.3
Significance	P= 0.01		
CV (%)	55.1		
LSD	3.0		

Data represents means of the experiment repeated three times with 30 replicates per treatment.

With the increase in concentration of $AgNO_3$ from 1 to 10 μM, the frequency of somatic embryogenesis increased (Table 5). However, the control (medium without $AgNO_3$) showed the highest frequency of somatic embryogenesis. In the case of

plant regeneration frequency, application of 5-10 μM $AgNO_3$ caused a significant improvement when compared to the control (Table 5).

Table 5. *The effect of $AgNO_3$ on somatic embryogenesis and plant regeneration*

Concentration of $AgNO_3$ (μM)	Somatic embryogenesis (%)	Plant regeneration (%)
0	37.7	5.9
1	22.3	3.8
5	33.6	8.0
10	35.8	6.3
Significance	p= 0.01	p= 0.05
CV (%)	6.4	4.8
LSD	1.0	0.3

Data represents means of the experiment repeated five times with 30 replicates per treatment.

Further studies on the synergistic effect of ABA, high agar-induced water stress, cytokinin and $AgNO_3$ on somatic embryogenesis and plant regeneration might be useful in increasing the plant regeneration efficiency.

During the year, ten plants regenerated from plumule-derived callus were planted in the field.

S C Fernando and L K Weerakoon

Experiment 18.2.6. Studies on cell suspension culture of coconut (1997)

Friable callus is the most suitable starting material for initiation of cell suspensions. Thus attempts to obtain friable callus from initial explants or compact callus were continued. Previous experiments showed that culturing of crushed compact callus in a solid medium for about 30 days followed by the transfer to a liquid medium results in the production of small callus clumps. These clumps could be easily separated from mother tissues. However, proliferation of these clumps was slow. Therefore, attempts were made to improve the rate of cell proliferation in small callus clumps (Table 6).

Table 6: *Effect of different treatments on callus proliferation*

Tissue	Treatment	Observation
Compact callus	a) Application of 0-300 mgl^{-1} casein hydrolysate.	Improved the formation of small callus clumps.
	b) Application of 50-100 µM of picloram.	Improved the formation of small callus clumps.
Immature inflorescence	c) Application of 0-300 mgl^{-1} casein hydrolysate.	300 mgl^{-1} casein hydrolysate improved the formation of small callus clumps.
	d) Application of 50-100 µM of picloram.	No significant effect on callusing.
	e) Application of 4-12 % sucrose.	12% sucrose improved the formation of small callus clumps.

When transferred to liquid medium (with shaking at 120 rpm), the small callus clumps proliferated. However, the dispersion of cells from mother clumps was not observed.

Furthermore, the effect of genotype on friable callus initiation was tested. Plumules excised from mature embryos of five different genotypes (Sri Lanka Green Dwarf, Sri Lanka Yellow Dwarf, Sri Lanka Tall (Dikiri), Sri Lanka Tall (Moorock) and Sri Lanka Green Dwarf X Sri Lanka Tall) were cultured into callus induction medium but none of them produced friable callus.

S C Fernando

Experiment 18. 2. 7.Studies on coconut anther, pollen and ovule culture (1997)

The developmental stage of pollen within anthers of an individual flower bud is a critical factor in haploid induction. Routine cytological examination of pollen for determining the correct stage for culture is tedious and time consuming. Thus it is convenient to resort to an external marker for collecting anthers at the correct developmental stage without testing each one of them before culturing. A study was undertaken to identify any correlation between pollen developmental stage and the age of the spadix in terms of Weeks Before Splitting (WBS), in Sri Lanka Tall coconut under local environmental conditions.

Cytological observations of pollen development was carried out with newly opened spadices as well as with those collected at 1-8 WBS. Usually, at a given time, two successive unopened spadices were visible on a tree. However during dry weather, only one unopened spadix could be seen clearly and the second one was hardly visible. The cytological observations are summarized in Table 7.

Studies have shown that the microspores at uninuleate stage were highly embryogenic. Therefore uninuleate stage could be regarded as the most suitable stage for androgenesis. According to the results, late uninuleate stage corresponds to spadices of 3 WBS (Table 7) and therefore it can be assumed that anthers from spadices of 3 WBS stage are suitable for anther and pollen culture. However, under severe drought conditions, the correlation between stage of pollen development and the age of the spadix was slightly different. Pollen mother cells could be observed in 4 WBS spadices. When compared to normal weather conditions, the time taken for production and maturation of pollen grains was shortened by one month during drought. Thus under drought conditions, anthers from 2 WBS spadices could be used for haploid culture.

Table 7. *Different stages of pollen development in relation to age of the spadix (WBS) in coconut*

Age of Spadix (WBS)	Description of developmental stage
8	Microspore mother cells (MMC)
7	Isolated MMCs and tetrads after meiosis
6	Released oblong shaped microspores in early uninucleate stage
5	Spherical shaped microspores
4	Microspores with vacuoles and thick exine in mid uninucleate stage
3	Spherical microspores with distinct nucleus in late uninuleate stage
2/1	First pollen mitosis
1/newly open	Binucleate pollen grains with internal deposits.

Preliminary investigations on ovule culture were initiated. A study was undertaken to identify the most suitable developmental stage for callus induction. Ovules obtained from inflorescence of –1 to –6 stages (considering the youngest open inflorescence as 0) were cultured into callus induction medium. Callus production was observed only in the explants obtained from –4, -5 and –6 stages.

Further studies were undertaken to select the optimum conditions for callusing. Ovules obtained from inflorescence of –4, -5 and –6 stages were cultured into basal medium 72 containing different concentrations of activated charcoal (0.1, 0.25 and 0.3%) and 2,4-D (50, 100 and 200 µM). Highest percentage of callusing (30%) was observed in ovules of –4 stage cultured in the medium containing 0.1% activated charcoal and 100 µM 2,4-D.

P I P Perera, S C Fernando and L K Weerakoon

Experiment 18.2.10 : Biochemical studies on coconut (2001)

Determination of embryogenic potential of tissues at an early stage of *in vitro* culture would be of great value for selecting potential cultures and increasing the plant regeneration efficiency. Accumulation of several bio chemicals (proline, total

sugar, starch, ABA and protein) during the process of somatic embryogenesis was studied with the objective of finding a biochemical marker for embryogenesis in coconut. Biochemical characterization of zygotic tissues was also undertaken as a reference to identify possible biochemical markers. Zygotic embryos (Sri Lanka Tall) at different maturity (9-16 months post anthesis), plumule-derived callus and cultures having different morphological features after inducing somatic embryogenesis were used for the analysis.

Among the different embryo maturity stages tested, the highest content of proline (2.9 mg g^{-1} DW) was present in the embryos of stage 11. A gradual decrease in the proline content was observed with increasing maturity. Despite the decreasing trend, there was a very high variation (CV = 81.6 %) in the proline level of embryos collected from individual palms (Table 8).

No significant change was observed in contents of total sugar and ABA with embryo maturity (Table 8). Similar results were observed in the content of starch. However, experiment on starch content could not be repeated to confirm the results due to technical problems.

As shown in Table 9, upon subculturing of callus to a medium containing a lower level of 2,4-D, the callus accumulated higher proline. Further subculturing of callus into the regeneration media (medium with ABA followed by a hormone-free medium) resulted in cultures with variable morphological characteristics (types 3a-4b) and proline contents. The results also indicated that there was no significant variation in the content of total sugars in different types of tissues (Table 9).

Table 8. *Content of proline, total sugar, starch and ABA in zygotic embryos*

Maturity stage of embryo	Content of proline (mg g^{-1}DW)	Content of total sugars (g g^{-1}DW)	Content of starch (as sugar equivalents) (g g^{-1} DW)*	Content of ABA (ng ml^{-1} sap)
11	2.90	0.56	0.16	118.5
12	2.57	0.42	0.20	111.6
13	1.06	0.47	0.12	111.7
14	0.28	0.45	0.17	131.0
15	0.27	0.45	0.19	134.7
16	NT	NT	0.13	129.5
CV (%)	81.6	29.2		20.0
Significance	p=0.01	NS		NS
LSD	1.5	-		-

Content of proline and total sugars was measured in six replicated samples. * Content of starch was measured in a single sample. DW = Dry weight; NS = Not significant; NT = Not tested.

As this study was aimed at developing an early marker for somatic embryogenesis, determination of variation in content of bio chemicals in cultures treated with ABA was given importance and they were analyzed separately. The results are shown in Table 10.

The results revealed that the cultures with embryogenic structures had the lowest content of proline and total sugar. A significant difference in the levels of proline and total sugar in the cultures having embryogenic and non embryogenic structures (except type 3b) was observed (Table 10).

Analysis of ABA in *in vitro*-cultured tissues showed that they contained lower levels of ABA when compared to the zygotic tissues. Cultures within a given type of tissues showed a very high variation in ABA level and conclusive results could not be obtained.

Content of starch in *in vitro*-cultured tissues could not be determined due to technical problems.

Preliminary studies were conducted on analyzing soluble proteins in zygotic embryos and *in vitro*-cultured tissues of coconut. The electrophoretic pattern of soluble proteins extracted from mature zygotic embryos (9-16 month post anthesis) showed the presence of several major and minor bands with different intensities at different maturity stages. The electrophoretic pattern of soluble proteins extracted from *in vitro*-cultured tissues showed the presence of some major protein bands similar to the bands obtained from zygotic embryos. The intensities depended on the tissue type. However, no embryogenic-specific proteins were detected.

Among the bio chemicals studied, total sugars seems to be an appropriate biochemical marker. Analysis of total sugars and sugar profile in cultures at early stages of somatic embryo induction might generate useful information for developing a biochemical marker.

Preliminary studies on developing a molecular marker of embryogenesis were conducted. Expression of Retinoblastoma (Rb) gene (a cell cycle controlling gene) in embryogenic and non-embryogenic callus was studied using ddRT-PCR technique. RNA was extracted from plumule-derived, embryogenic and non-embryogenic callus. Experimental conditions were optimized for RT-PCR for Rb gene in the presence of an internal standard. The results revealed that expression of Rb gene in non-embryogenic callus was higher than that of embryogenic callus indicating the possibility of using Rb gene as a marker to screen embryogenic callus.

Table 9. *Content of proline and total sugar in in vitro-cultured tissues*

Type of *in vitro*-cultured tissue	Content of proline (mg g^{-1}DW)	Content of total sugars (g g^{-1}DW)
1. Embryogenic callus	1.51	0.19
2. Embryogenic callus maintained in lower 2,4-D containing medium	2.78	0.18
3. Cultures treated with ABA:	0.65	0.11
3a. Cultures having embryogenic structures		
3b. Cultures having shoot-like structures with haustorial-like texture	1.37	0.13
3c. Cultures having haustorial type tissues	2.32	0.18
3d. Cultures having non-embryogenic yellowish callus	3.19	0.16
4. Further developed cultures of type 3a:	0.92	0.12
4a. Cultures having elongated embryogenic structures		
4b. Cultures having haustorial type tissues	0.67	0.15
CV (%)	64.7	29.0
Significance	p = 0.01	NS
LSD	1.40	-

DW = Dry weight; NS = Not significant.

Table 10: *Content of proline and total sugars in cultures with different morphological characters*

Type of *in vitro*-cultured tissue	Content of proline (mg g^{-1}DW)	Content of total sugars (g g^{-1}DW)
3a	0.65	0.11
3b	1.37	0.13
3c	2.32	0.19
3d	3.19	0.16
CV (%)	71.9	22.9
Significance	p = 0.05	p = 0.01
LSD	1.82	0.04

DW = Dry weight.

S C Fernando and L K Weerakoon

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 experiments and statistical analysis of data. Special thanks are extended to the Head and the staff of the Plant Physiology Division for their assistance in biochemical analysis of various explants of coconut.

REPORT OF THE COCONUT PROCESSING RESEARCH DIVISION
Officer in charge – C Jayasekara, Ph D

GENERAL

The research program of the Division gave more emphasis on developing kernel based value added products. Experiments conducted to develop healthy oil blend were further continued with a view to improve stability of the oil and quality of food preparations. The study revealed that acceptability of 10% and 25% sesame blends was greater than the other blends.

Experiments conducted to develop value added products revealed that defatting of coconut milk to give 5% fat and mixing with non - fat milk resulted in a mixture suitable for yoghurt and ice cream of an acceptable quality. Experiments were initiated to improve shelf life of scraped fresh coconut packed in polythene bags. Technology was developed to preserve *peni pol* in bottles.

Two beverages were developed out of seasoned coconut water and tender coconut water with the kernel. The taste and appearance of the products were acceptable and further experiments are being continued to improve shelf life of the products.

Experiments were continued to increase alcohol percentage in fermented toddy. A combination of sodium metabisulphite and isolated yeast strain cultured in the toddy medium increased the alcohol level from 5-6% to 9.6% under natural fermenting condition on the fifth day. A method will be developed to distribute this yeast isolate among toddy tapping community.

Studies on coir retting were started in the processing division to find out microorganisms which accelerate the retting process.

PROJECT 40.1: Fatty acid composition, preservation and value addition to coconut oil

Experiment 1 : Development of a healthy oil blend using coconut oil and sesame oil

Coconut oil is deficient in essential fatty acids such as linoleic acid and linolenic acid and total essential fatty acid content is less than 2%. Sesame oil is one of the locally available vegetable oil, which is rich in essential fatty acids. Essential fatty acid content of sesame oil is 45%. Vegetable oil has one type of dominating fatty acid, which can be a saturated fatty acid, a monounsaturated fatty acid or a polyunsaturated fatty acid. However, none of the common vegetable oils contains equal percentage of three types of fatty acids.

A vegetable oil containing an equal ratio of the three types of fatty acids could be considered as a wholesome oil. Coconut oil, which is rich in medium and short chain fatty acids rich saturated oil, is popular as cooking oil in Sri Lanka. In this study possibility of blending sesame and coconut oil was tested with a view to increase the health benefits of the oil blend.

As reported in the previous year (Annual Report 2000) 10% and 25% sesame oil blends with coconut oil were accepted as good vegetable oil blend for food types require deep frying. The present study was continued to evaluate the same blends for deep and shallow fried foods.

Unrefined, fresh coconut oil and sesame oil were used in this study. Coconut oil extracted from copra at CRI and sesame oil purchased from a milling site at Kekirawa area were used. The following samples were prepared.

Coconut oil: Sesame oil

1. 100 : 0
2. 90 : 10
3. 75 : 25
4. 0 :100

The following foods were prepared using the above oil blends.

1. Kavum
2. Kokis
3. Cutlet
4. Seeni sambol

The organoleptic properties of the above food items were tested by a taste panel of 35 panelists. Five point hedonic scale was used to evaluate the results.

The overall acceptability of all the food items prepared using 100% sesame oil was significantly different ($p<0.05$) from all the other blends. There was no significant difference among 100% coconut oil, 90:10 blend, and 75:25 blend for overall acceptability of Kavum and Kokis .The evaluation of a few selected deep fried foods by testing panels indicated that partial replacement of coconut oil with 10% or 25% sesame oil gives very little or no change in the overall acceptability of foods prepared using them.

The study showed that coconut oil and sesame oil, which is locally available essential fatty acid rich source can be blended at the ratios of 90:10 and 75: 25 to produce nutritionally rich consumer acceptable oil for cooking purposes.

C. Yalegama and M. Abeygunawardena

Experiment 2: The properties of oil blends before and after use

Vegetable oils used for deep frying gradually undergo certain chemical changes during the frying process. The most important changes are colour formation, oxidation, polymerization, and hydrolysis.

All foods that are fried contribute substances (phosphates, sulfur compounds, and trace metals) that collect in the fat during frying process. These substances can react with fat imparting dark colour to oil. Oxygen from the air reacts with the heated fatty acids during frying. The products formed in the oxidation can accelerate further

oxidation of fats. At room temperature, this is a slow process. However, at frying temperatures, oxidation can proceed rapidly. Excessive oxidation is often accompanied by polymerization. In this process, relatively small fat molecules combine to form very large molecules. This can result in foaming and gumming. Also water in food can cause hydrolysis of fat to produce free fatty acids.

Four types of vegetable oils were used to determine the chemical changes occurring during deep- frying.

1. Pure coconut oil - Represents a saturated oil
2. Pure sesame oil - Represents an unsaturated oil
3. 10% sesame and 90% coconut blend - Represents partially unsaturated oil
4. 25% sesame and 75% coconut blend - Represents partially unsaturated oil

Free fatty acid content and peroxide value were determined in fresh and used oils for a period of 2 months. Analysis was carried out in triplicate. Results are given in Tables.1, 2, 3 and 4. Each value is a mean of three analyses.

Table 1. *Free fatty acid content of fresh oils during storage*

Coconut :sesame	Free Fatty acids content % (As lauric acid)		
	Fresh	After 30 days	After 60 days
100:0	0.32	0.34	0.36
90:10	0.62	0.65	0.75
75:25	1.08	1.15	1.20
0:100	2.57	2.83	3.14

Table 2. *Free fatty acid content of used oil during storage*

Coconut :sesame	Free Fatty acids content % (As lauric acid)					
	Cutlet			Kokis		
	Just after frying	30 days after frying	60 days after frying	Just after frying	30 days after frying	60 days after frying
100:0	0.41	0.41	0.42	0.24	0.28	0.35
90:10	0.56	0.56	0.58	0.43	0.45	0.53
75:25	0.67	0.70	0.77	0.60	0.63	0.92
0:100	2.62	2.70	2.85	2.55	2.62	2.93

As given in the Tables 1 and 2 free fatty acid content of fried oil is less than the fresh oil. This is due to the evaporation of free fatty acids (FFA) at high temperatures used in deep-frying. Free fatty acid content in fried oil used for cutlets is higher than the oil used for making kokis. Cutlets contain fish oil, which can contribute to FFA content of fried oil. The pattern of variation of FFA values of fried oil is more or less similar to that of fresh oil.

Table 3. *Peroxide value of oil blends during storage*

Coconut :sesame	Peroxide value meq/kg		
	Fresh	After 30 days	After 60 days
100:0	4.5	4.9	5.0
90:10	4.6	5.6	7.6
75:25	4.6	6.6	11.0
0:100	4.8	8.0	15.9

Table 4. *Peroxide value of used oil blends during storage*

Coconut :sesame	Peroxide value meq/kg					
	Cutlet			Kokis		
	Just after frying	After 30 days	After 60 days	Just after frying	After 30 days	After 60 days
100:0	6.0	9.2	12.5	16.4	29.4	50.6
90:10	4.4	7.6	11.4	15.5	25.0	58.0
75:25	5.4	9.0	13.6	23.6	46.2	88.0
0:100	4.4	9.6	15.0	17.8	53.4	320.5

Peroxide value of fresh oils was similar in all samples. There was an increasing trend of peroxide value for all oils with storage. Increase was higher when sesame oil percentage was high. As given in the Table-3 peroxide value of fresh sesame oil increased 3 fold after keeping 60 days. Where as the results of Tables 3 and4 are considered, peroxide value of fried oil used for kokis is always higher than that of fresh oil. Highly unsaturated fatty acids easily undergo oxidation to form peroxide. This tendency increases with the temperature and the time taken for frying. Normally frying cutlet takes lesser time than kokis making. There is no standard for the peroxide value for vegetable oils even though it affects the quality of oils. Vegetable oils are not suitable for re-use as there quality is altered during deep frying. This tendency is greater for unsaturated vegetable oils than saturated oils like coconut oil.

C. Yalegama and M. Abeygunawardena

Experiment 3: Studies on retained oil in the food during frying

This study was carried out to find out the relationship between the oil retained in the food during frying and the nature of the oil. Oil blends of saturated and unsaturated oils were used in this study.

The quantity of oil retained in cutlet, kokis and kavum was determined by extraction of oil with petroleum ether for 8 hours. The results are given in Table- 5. Each value is a mean of 4 replicates.

Table 5. *Retained oil percentage in prepared food*

Oil blend	Oil content %		
	Cutlet	Kokis	Kavum
100:0	15.0	11.2	13.9
90:10	20.2	10.8	15.5
75:25	13.6	9.9	12.0
0:100	13.7	13.1	10.6

The amount of fat absorbed depends on the time food takes to cook, surface area of the food and the nature of the food. According to the results there is no relationship between retained oil and the oil blends.

C. Yalegama and M. Abeygunawardena

PROJECT 41.0: Research on development of coconut kernel based products.
Experiment 1 : Preparation of ice cream from coconut milk

Good quality ice cream was prepared according to the cottage manufacturing practice with coconut milk and non-fat milk powder in the ratio of 1: 1 as a household process. The quality was determined in respect of the taste with different flavoring agents such as vanilla, almond and chocolate. Ice cream with vanilla and almond flavours gave coconut taste but the one with chocolate flavour gave different taste which tasting panel liked most. Results are given in Table 6.

Table 6. *Taste of ice-cream with different added flavours*

Type of flavour	Taste
Vanilla	Coconut
Almond	Coconut
Chocolate	Good

M. Jayasundera, C.Yalegama and A.N.Kumara

Experiment 2: Preparation of yoghurt using coconut milk as the main substrate

The efforts were continued to overcome the layer separation previously encountered. The coconut milk was centrifuged at 5,000 rpm at 4° C for 30 minutes prior to making yoghurt. The oil layer separated after centrifugation can be used as pure coconut oil, which can be marketed at a higher price. The improved product was of good setting quality. The composition of the yoghurt so prepared is given in Table 7. Each value is a mean of three analyses.

Table 7. *Composition of yoghurt*

	Moisture %	Fat %	Protein %	Total Sugar %
Yoghurt	85.7	3.5	4.8	6.0

pH and the acidity of the yoghurt were 4.5 and 0.74 % as lactic acid respectively. The cost of production of yoghurt is Rs 8.00 per cup.

Further studies are being continued to reduce the cost of a cup of yoghurt.

Experiment 3 Preservation of fresh coconut in the form of gratings by combination preservation technique

The main objective of this study was to develop a method to extend the shelf life of fresh grated coconut to make it available as ready to use packs.

Preliminary experiments were carried out to determine the levels of humactants, acidulants and preservatives. Scraped coconut was mixed with salt (NaCl) and sugar at different levels as given in Table 8. The best humactant level was selected by measuring the water activity of the sample.

Table 8. *Effect of different humactants on water activity*

	Water activity	Organoleptic quality
Fresh coconut	0.99	Palatable
Salt 1%	>0.94	Palatable
2%	>0.94	Tolerable saltiness
3%	0.93	Tolerable saltiness
4%	0.92	Saltiness not tolerable
Sugar 15%	0.98	Sweet
20%	0.97	Sweet

The limiting water activity for most food poisoning bacteria including Salmonellae and Clostredia in foods is 0.95 (Russell, 1991). Table 8.0 shows that it is difficult to reduce the water activity further because of alteration of organoleptic properties. According to this study, salt at 3% was identified as a humactant to be used and it was found that citric acid and tri sodium citrate at 0.3% and 0.1% respectively is adequate to reduce the pH of coconut up to 4.5. Sodium benzoate at 0.05% is used as a preservative (Jay, 1996). Studies are being continued.

P Gunathilaka and L. Dassanayake

Experiment 4: Studies on development and storage of bottled "Peni pol" (Coconut Caramel Spread)

"Penipol" (Coconut Caramel Spread) is a coconut based product made out of grated coconut, caramelized sugar or treacle, salt and few selected spices. This is used as an ingredient or 'sweet filler' in the preparation of various traditional foods. However, *panipol* cannot be kept for more than two days without refrigeration because of rancidity development and microbial spoilage. Main objective of this study was to develop an instant product by applying the sterile bottling technique, which extends the shelf-life of food product. In this process, food and its container are commercially sterilized by the application of heat or in combination of pH and water activity (Cruess, 1958).

Preliminary experiments were carried out to determine the best proportion of raw materials for an acceptable product. Table- 9 shows the blends used in the study.

Table 9. *Coconut and caramelized sugar (85^0) ratios for Penipol formulation*

Formulation	Blends	Observations	Acceptable or not
1	Coconut 2.0kg Caramel sugar 2.0kg	Taste-good Colour-good Texture-too juicy	Unacceptable
2	Coconut 2.5kg Caramel sugar 2.0kg	Taste-good Colour-good Texture-good	Acceptable
3	Coconut 3.0kg Caramel sugar 2.0kg	Taste-good Colour-light Texture-good	Unacceptable
4	Coconut 3.5kg Caramel sugar 2.0kg	Taste-good Colour-too light Texture-good	Unacceptable

Formulation 2 was selected for further experimental work.

Intrinsic parameters of "Peni pol" prepared with this recipe were measured to determine required processing conditions.

Table10. *Intrinsic parameters of Penipol*

Parameter	Value
Total Soluble Solids	65%
pH	5.5
Water activity	0.8

With this preliminary study bottling techniques of "Peni pol" will be developed and shelf life will be evaluated at different sterilization conditions.

P. Gunathilaka and A.N Kumara

Experiment 5: Development of a coconut milk extraction machine for household use

Hand squeezing is the widely used method of coconut milk extraction at domestic level.. Although the blender is used to get more milk in urban households , it is not cost effective as it needs electricity. Therefore hand operated milk extractor was designed and developed using low cost materials for household use.

This machine comprised of 5 parts, cylindrical body, milk collector, piston, handle, and stand. It was made of PVC to minimize the cost.

Advantages of the extractor

1.Extraction of high quantity of coconut milk.
2.Hand operated
3..Easy maintenance
4. Low cost raw materials.

5. This can be used for other purposes such as fruit juice extraction.

To compare the efficiency of the extractor with hand squeezing method, the following experiment was carried out.

Hundred grams (100g) of scraped coconut was mixed with 100ml of water and coconut milk extracted by using both coconut milk extractor and hand squeezing method separately. The extraction was repeated 3 times, each time adding 100ml of water. The quality of the extracted coconut milk was analyzed separately. Results of the analyses are given in Table 11.

Table 11. *Composition of milk and residue by the two methods of extraction*

	Method of Extraction	
	Hand squeezing	coconut milk extractor
Total weight of milk extracted (g)	329.33	359.33
Moisture content of milk (%)	89.97	89.79
Weight of the Residue (g)	57.76	31.53
Moisture content of residue (%)	76.59	60.47
Fat content in the extracted coconut milk (%)	10.24	9.82
Fat content in the extracted scraped coconut (g)	33.72	35.31

According to the results, the obtainable quantity of coconut milk using the coconut milk extractor was higher than the hand squeezing method. Also extractable fat in milk compared to the fat content in scraped coconut by the extractor was higher than the hand squeezing method. Hence, good quality coconut milk can be obtained by using this coconut milk extractor.

A.R. Kulathunga

PROJECT 42.0: Products based on coconut water
Experiment 1 Development of beverage using seasoned nut water

Main objective of this study was to develop a palatable beverage, storable at the ambient temperature using seasoned nut water.

Two formulations with natural lime juice and commercial citric acid with lime flavour were tested. Different levels of heat treatments were applied for bottled beverages as given in the Table- 12. Based on the total plate counts appropriate heat treatment was selected. It was observed that pasteurization at 80^0 C for 10 min. was sufficient to achieve commercial sterility of the beverage from seasoned nut water.

Table12 . *Effect of heat treatment*

Heat treatment	Total plate count
70^0C for 10 min	25 /ml
80^0C for 10 min	nil
90^0C for 10 min	nil
100^0C for 10 min	nil

During the storage period, sedimentation and layer separation was observed in the product. Therefore different levels of Carboxy Methyl Cellulose (CMC) and pectin were added separately and compared the sedimentation as given in Table 13 to identify a suitable stabilizer to be used. By the visual observations it was found that 4% CMC was better than pectin in the case of cloud stability of the product. Therefore 0.4% CMC was selected as a suitable stabilizer.

Table13. *Effect of stabilizer on product stability*

Stabilizer	Degree of sedimentation
CMC 0.2%	High
CMC0.4%	Low
CMC0.6%	Low
Pectin 0.2%	High
Pectin 0.4%	Medium
Pectin 0.6%	Medium

The effect of different levels of homogenization was also tested on cloud stability. It was observed that homogenization gave a satisfactory physical stability for the product.

P. Gunathilaka and W.Bandara

Experiment 2: Development of tender coconut water beverage with its kernel

The main objective of this experiment was to develop a beverage out of nut water and kernel of tender nuts. The tender coconut kernel contains higher percentage of essential fatty acids, amino acids and other nutrients compared to the mature kernel.

Preliminary trials were conducted to identify suitable ingredients in the formulation and processing conditions of the product. It was found both natural lime juice and commercial citric acid could be used as acidulant as well as flavoring agent. It was observed that pasteurization at 100^0C for 5 min. is sufficient to get a microbiologically safe product. Homogenization at 11000 rpm was sufficient only for a temporarily stable product since separation of kernel and water was observed within a short period of time. To overcome this situation pectin was added in different quantities as given in the Table-14 to get a physically stable product. Based on visual observations, the appropriate level of pectin was selected.

Table 14. *Effect of pectin on stability*

Pectin (%)	Degree of stability
0.1%	Low
0.2%	Low
0.3%	Low
0.4%	High
0.5%	High
0.6%	High

Pectin at 0.4% level was identified as a stabilizer to get a stable product without separating kernel and water. Further studies are being continued to improve shelf life.

PROJECT 43.0: Research on coconut Toddy

Experiment 1 Use of Sodium metabisulphite to increase ethanol production of coconut toddy

Naturally fermented toddy contains approximately 7% of alcohol. However, alcohol percentage could be increased by using chemicals. Sodium metabisulphite was added into collecting pots in varying concentrations (0-250 ppm) and ethanol concentration was measured for seven consecutive days. The sap treated with 151-200 ppm of sodium metabisulphite reported 8.59 % (v/v) ethanol on the fourth day of fermentation. The highest ethanol yield for sap treated with 201-250 ppm of sodium metabisulphite was 9.2 % (v/v) on the sixth day of fermentation. The results are shown in Table 15.

Table 15. *Variation of mean ethanol concentration with different concentrations of sodium metabisulphite*

Day	Sodium metabisulphite concentration (ppm)						
	0	1-50	51-100	101-150	151-200	201-250	>250
1	1.21	1.25	1.11	1.21	0.93	0.89	0.84
2	3.57	2.93	3.70	3.79	4.89	3.45	3.58
3	5.89	5.82	7.59	7.61	7.10	7.32	7.12
4	6.71	6.13	7.88	7.68	8.59	8.11	7.80
5	6.50	5.11	7.71	7.90	8.50	8.60	8.12
6	5.10	4.70	6.90	7.71	6.62	9.20	8.00
7	4.51	4.12	5.41	6.90	6.19	7.98	7.18

Mean ethanol yields were calculated by taking ten replicates per each group into consideration.

M. Jayasundera and A.Morawakaarachchi

Experiment 2 Use of Sodium metabisulphite and yeast isolates on the ethanol production of coconut toddy

Sixteen new cultures were isolated from fermenting coconut toddy treated with sodium metabisulphite using pour plate and streak plate methods. All the isolates showed high alcohol concentration on the fifth day of fermentation under control conditions. Sap inoculated with one of the isolated yeast cultures (Y_{16}) at the time of sap collection showed the highest ethanol concentration of 9.4 % (v/v).

When sap was treated with sodium metabisulphite along with yeast isolates Y_3, Y_{10} and Y_{16}, the ethanol production increased to a higher level compared to that with yeast isolates alone (Table 16).

Table 16. *Ethanol production of sap inoculated with yeast isolates, Y_3, Y_{10} and Y_{16} along with addition of sodium metabisulphite of three different concentrations under field conditions.*

Yeast Isolate Number	Sodium metabisulphite concentration (ppm)	Ethanol Concentration (% v/v) Day 3	Day 4	Day 5
Y_3	0	7.4	7.6	7.3
	100-150	8.2	8.6	8.9
	151-200	8.4	8.7	8.9
Y_{10}	0	8.9	8.3	7.9
	100-150	8.8	9.3	9.2
	151-200	8.1	8.8	8.9
Y_{16}	0	6.5	9.1	9.4
	100-150	9.3	9.6	9.6
	151-200	8.9	9.0	9.4
Control	0	6.8	7.5	6.8
	100-150	7.6	7.7	7.9
	151-200	7.0	8.6	8.5

Addition of 100-150 ppm of sodium metabisulphite along with yeast isolates was effective rather than adding of > 150 ppm of sodium metabisulphite along with yeast isolates. The highest concentration ethanol of 9.6% was observed in sap inoculated with $Y_{16\ isolatee}$ with addition of Sodium metabisulphite (100-150 ppm) on the fifth day of fermentation. Use of either method would enhance the ethanol concentration of coconut toddy.

The yeast isolates are maintained by sub culturing every three months.

M. Jayasundera , A. Morawakaarachchi and A.N. Kumara

(3) Research projects funded by outside agencies.

Experiment 1 Studies on the retting process of coconut fibre to improve the quality of coir fibre.

Comparison of microbial community in fresh water, brackish water and saline water retting pits.

Traditional process of extracting fibre from coconut husks involve initial period of soaking in fresh water or brackish water for 3-4 weeks, followed by mechanical separation of fiber. White fibre is produced by subjecting to a long retting process, which takes around 10-11 months.These conventional methods used for the extraction of brown and white fiber are not profitable due to long retting period, environment pollutions, stringent standards of quality demanded by foreign buyers and shortage of labour to work in soaking pits.

Therefore this study was started with the objective of developing methods to obtain high quality coir fibre within a short period of retting. First, a comparison study

was carried out to understand the microbial flora present in all three types of retting pits, namely, fresh water, brackish water and saline water.

Eight sampling sites were selected for this study which comprised of three fresh water and two brackish water retting pits from the northwestern province and three saline water retting pits from the southern province. Sampling was done at three weekly intervals and the ret liquor collected was subjected to microbiological as well as physicochemical character analysis. Many bacteria and few fungi were isolated .The dominating organism in all three types of water was found to be a spore forming Bacillus. Among the fungi Mucor and Aspergillus and some yeast strains were found to be dominating. These organisms have been identified up to genus level and the species level identification and study of enzymatic activity of these organisms is yet to be done to formulate an artificial microbial consortium to accelerate the retting process. Identified bacteria and fungi are as follows.

Identified bacteria –

1. Bacillus
2. Clostridium
3. Pseudomonas
4. Alcaligens
5. E.coli
6. Enterobacter
7. Kurthia

Identified Fungi

1.Aspergillus
2.Mucor
3.Yeast

F. Farook, A. Tennakoon and A.R.Kulathunga

4. Laboratory and miscellaneous studies

1. Observation of growth of microorganisms in coconut milk and coconut oil extracted by the coconut oil extractor introduced by NERD.

The machine introduced by NERD was designed to extract coconut oil for household consumption. Scraped coconut has to be dried for 2-4 hours until the oil is detected on pressing by fingers. During this period microbial contamination can occur. The objective of this study was to find out whether the microbial contamination would occur in scraped coconut, oil and milk obtained by sun - dried coconut.

One half of scraped coconut (300 g) was sun - dried for 2 hours while the other half (300 g) was oven dried at 50 ^{0} C for 2 hours. Firstly, the oil was extracted with both the sun dried and oven dried coconut by using the extractor. Secondly, milk was extracted by adding water to the residues of both sun dried and oven- dried coconut. Coconut oil, milk and scraped coconut were inoculated (pour plate method) to the following media.

(1) Potato dextrose agar (Tetracycline was added as a bacterial inhibitor)
(2) Nutrient agar

The plates were covered with parafilm and kept at room temperature. After 2 days of inoculation, the microbial growth was observed. The colonies were observed through the naked eye and under the microscope. The results are given in Table- 18.

There is no appreciable difference in microbial growth in oil, milk or coconut whether coconut is oven - dried or sun- dried.

Table 18. *Growth of micro organisms inn oil/milk/Coconut*

Oil/Milk/Coconut	Growth of micro organism
Sun - dried oil	Mucor, Aspergillus, Penicillium (Fungi colonies) Bacterial colonies
Oven - dried oil	Mucor, Aspergillus, Penicillium (Fungi colonies)
Sun - dried Milk	Mucor, Aspergillus, (Fungi colonies) Bacterial colonies
Oven - dried Milk	Mucor, Aspergillus, (Fungi colonies) Bacterial colonies
Sun - dried coconut	Mucor, Aspergillus, (Fungi colonies) Bacterial colonies
Oven - dried coconut	Mucor, Penicillium, (Fungi colonies) Bacterial colonies

M. Jayasundera, C.Yalegama and A.N.Kumara

Studies on the change of peroxide value of vegetable oils with temperature

Antioxidants have been added to vegetable oils in the market as preservatives to prevent formation of peroxides. The reason is that unsaturated bonds in vegetable oils react with oxygen to form peroxides. This could be continued as a chain reaction in the absence of antioxidants.

In this study, four types of vegetable oils were used. Except coconut oil, others were treated with antioxidants. Peroxide value was determined at different temperatures. The results are given as the mean value of 3 determinations.

As shown in Table-19 coconut oil had the lowest peroxide value at room temperature (1.0 meq/kg) Soya oil had the highest (10 meq/kg) .At cooking temperature (150°C) coconut oil had the lowest value (3 meq /kg) and Soya oil had the highest value (11 meq/kg).

Although coconut oil is highly saturated it has a tendency to form peroxide due to the oleic acid content (6%). Therefore adding antioxidants to coconut oil will increase the shelf life of coconut oil.

Table 19. *Peroxide values of vegetable oils at different temperatures*

Kind of vegetable oil	Peroxide Value/meq/kg		
	30°C	150°C	250°C
Soya oil	10.00	11.40	10.20
Corn oil	6.60	9.40	10.40
Palm oil	7.60	8.60	11.00
Coconut oil	1.00	3.00	8.00

Coconut oil contains approximately 90% of saturated fatty acids, which are stable. Other vegetable oils contain approximately 75% of unsaturated fatty acids which are active and produce free radicals in the presence of oxygen. Formation of peroxides is prevented by addition of antioxidants during the processing of vegetable oils. However, coconut oil is pure and free from preservatives.

C. Yalegama and M. Jayasundera

Experiment 41.1.5 Efficiency of different techniques on extraction of coconut milk

Coconut milk was extracted using 5 methods Viz., hand squeezing, blending (electric blender), oil extraction machine made by NERD and hydraulic pressing machine. In each case, milk extraction was performed three times by adding water at 1:1 ratio. According to the results in Table 20, hand squeezing gave the lowest yield of coconut milk and the highest coconut residue weight. Hydraulic press gave the highest yield of coconut milk and the lowest residue weight. Hand squeezing and domestic blender extracted the highest fat content with the milk while NERD machine extracted the lowest oil content with milk (20.2-14.4%). Protein content of the milk was in 1-2 % range for all the methods. It can be concluded that the machine introduced by NERD gives low fat milk with fresh meat. The milk yields of the blender and grinding stone methods were lower than the NERD machine and the hydraulic press method but higher than the squeezing method. The milk yield was the lowest in the squeezing method.

Table 20. *Effects on different extraction techniques on the quality of coconut milk.*

Treatment	Weight of milk(g)	Moisture content of milk %	Fat %	Protein %
Hand squeezing	320.8^{c}	71.6^{c}	20.2^{a}	1.3^{c}
Domestic blender	344.2^{b}	69.5^{d}	20.8^{a}	1.7^{b}
Grinding stone	337.5^{b}	75.8^{b}	19.2^{b}	2.0^{a}
NERD oil extractor	355.0^{a}	83.2^{a}	14.4^{d}	1.1^{d}
Hydraulic press	361.9^{a}	75.1^{b}	16.5^{c}	1.5^{b}

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8. Other particulars

Laboratory and the office of Processing Research Division was shifted to a new building in August 2001.

9. Acknowledgements

The assistance and co-operation of the laboratory staff including Mahinda Rajapaksa of Coconut Processing Research Division is greatly acknowledged. Thanks are due to Dr. (Miss) S. Ranasingha, Head/ Plant Physiology Division and Dr. L.L.W.Somasiri, Head/ Soils and Plant Nutrition Division for the co-operation extended during the work. The funds given by CESS for retting studies is gratefully acknowledged.

REPORT OF THE PLANT PHYSIOLOGY DIVISION
Head – C S Ranasinghe, Ph D

1. GENERAL

The highest priority of the divisional research program was given to the studies on disorders of unknown etiology. A grant was received from Food and Agriculture Organization (FAO) for testing Coconut Rapid Decline-affected palms for the presence of phytoplasma and the work is continued in collaboration with Genetics and Plant Breeding and Crop Protection divisions.

Application of 3.0 ml of 2.5% ethrel at the axis of the tapping spadix increased the daily toddy yield, yield per spadix and sugar content in the sap consistently for a period of 4 years. The annual removal of N, P, K, Mg and C with the sap was greater from ethrel-treated palms than from untreated palms, and this was mainly attributed to the enhanced sap yields and sugar contents.

To prevent the fermentation of fresh sweet toddy in the collection pots, different plant materials were tested as antiferments. Tender papaya, fresh coconut husk and vanillin powder were identified as effective materials, in addition to Hal bark in the preliminary studies.

An experiment was conducted to determine whether the 'tapping process' acts as a stimulant for female flower differentiation in successive spadices and the duration taken to sense the stimulation. If the palms were continuously tapped for a period of one year and allowed to produce nuts a higher number of female flowers were present in the bunches emerged 24 months after the commencement of tapping.

To refine the existing protocol for the quality preservation of tender nuts and enhance the acceptance of the product in overseas markets, experiments were commenced to screen and select low toxic, contact fungicides to replace Benlate.

Physiological performance of CRIC60, CRISL98 and CRIC65 grown under plant house conditions, and in the field, at different soil moisture regimes was evaluated. There was a significant difference in the photosynthesis, water potential, transpiration, stomatal diffusive resistance, relative water content and water use efficiency of leaves between stressed and unstressed plants in all three varieties, both in the plant house and in the field, irrespective of the severity of stress level.

When the manure circle (1.75 m radius from the base) of coconut palms, grown in Andigama soil series, was mulched with black polythene, the palms indicated a higher water deficit condition and, when a 6" thick layer of coir dust is applied as a mulch ground cover, the palms showed an improved water status than unmulched palms during the dry period. The black polythene increased the soil temperature under the mulch by 1.2 °C whilst the coir dust decreased it by 1.1 °C compared to an unmulched palm.

The pattern of embryo sac development, epidermal cell growth of the outer skin (exocarp), changes in the volume of nut and nut water and kernel development during the fruit enlargement, from female flower to mature nut, were studied.

2. RESEARCH PROJECTS

PROJECT 13: TODDY TAPPING

Experiment 13.4: Chemical stimulation of toddy. Bandirippuwa Estate, Lunuwila (1996).

This study investigated the effect of ethrel on the yield, sugar content and nutrient removal of coconut inflorescence sap and its sustainability. The experiment was a completely randomized design with 12 replicates per treatment. A small piece of cotton wool soaked in a 3 ml solution of Ethrel (Ethephon), at a concentration of 2.5%, was placed at the axis of the tapping spadix (inside the outer bract). The application was done once per spadix and on the first day of slicing. The volume of toddy per palm was measured daily, and sugar and nutrient content of toddy was measured monthly. Untreated palms were used as control.

Application of 3.0 ml of 2.5% ethrel at the axis of the tapping spadix increased the yield of fresh toddy per day and per spadix through out the experimental period of four years. However, the increase was not statistically significant in the third year possibly due to the high variation of yield among the palms (% CV = 51%). The stimulatory effect was less in the third year compared to the first, second and fourth years (Table 1). Ethrel application increased the sucrose and total sugar contents in the sap consistently over four years (Table 2), the total mean increase being 17%.

Table 1. *Effect of application of ethrel (2.5% E) on the yield of fresh sap during past four years.*

Treatment	Yield of sap							
	1st yr in tapping Nov 97 – Oct 98		2nd yr in tapping Nov 98 – Oct 99		3rd yr in tapping Nov 99 – Oct 00		4th yr in tapping Nov 00 – Dec 01	
	ml/day	L/spadix	ml/day	L/spadix	ml/day	L/spadix	ml/day	L/spadix
2.5% E	833	20.8	898	18.0	707	14.13	657	19.70
Control	634	15.9	626	12.5	619	12.39	504	15.12
LSD	150	4.1	172	4.6	259	4.1	101	2.1
Sig	*	*	*	*	ns	ns	**	**
% increase	31%		44%		13%		30%	

Table 2. *Effect of application of ethrel (2.5% E) on sugar content (g/100ml) in fresh sap during past four years.*

Treatment	Year of tapping							
	1st Nov 97 – Oct 98		2nd Nov 98 – Oct 99		3rd Nov 99 – Oct 00		4th Nov 00 – Dec 01	
	Sucrose	Total sugars	Sucrose	Total sugars	Sucrose	Total sugars	Sucrose	Total sugars
2.5% E	14.3	16.90	13.65	16.24	14.31	16.82	14.96	17.82
Control	12.40	13.96	12.39	14.20	12.40	14.06	12.01	12.64
LSD (0.05)	1.21	1.80	1.91	1.72	1.20	1.37	1.11	1.60
Sig	*	*	*	*	*	*	*	**

* significant at p=0.05 level, ** significant at p=0.01 level, ns, not significant

There was no difference in the concentration of N, P, K and Mg in the sap between ethrel treated and untreated palms (Table 3).

Table 3. *Effect of application of ethrel (2.5% E) on concentration of N, P, K and Mg (ppm) in fresh sap.*

Treatment	N	P	K	Mg
2.5% E	0.047	0.015	0.216	0.004
Control	0.044	0.015	0.203	0.004
Sig.	ns	ns	ns	ns

The annual removal of major elements (C, N, P, K and Mg) was higher from ethrel-treated palms than from the control palms throughout the years (Table 4). Whilst an untreated coconut palm removed 13-14 kg of carbon as sap, an ethrel treated palm removed 16-20 kg per palm annually. The increased removal of carbon in the sap by stimulated palms was both due to higher concentration of sugars (Table 2) and higher sap volume (Table 1) whereas the increased removal of other nutrients was entirely due to the increased volume of sap removed annually. The relative order of nutrient removal by the sap was K> N> P> Mg (Table 4).

Table 4. *Effect of application of ethrel (2.5% E) on the removal of carbon (kg / palm / yr) and major nutrients, N, P, K and Mg (g / palm / yr) by the sap during the past three years. Calculations are based on the total volume of sap collected during each year.*

Element	Treatment	1st year Nov 97 – Oct 98	2nd year Nov 98 – Oct 99	3rd year Nov 99 – Oct 00	4th year Nov 00 – Dec 01
C	2.5% E	18.25	20.36	16.02	14.87
	control	13.98	14.19	14.05	11.47
N	2.5% E	154.45	171.27	134.81	125.08
	control	117.61	119.36	118.19	96.46
P	2.5% E	30.89	34.26	26.96	25.49
	control	23.52	23.87	23.64	19.29
K	2.5% E	679.56	753.59	593.15	550.35
	control	517.46	525.17	520.02	424.42
Mg	2.5% E	12.40	13.70	10.80	10.01
	control	9.40	9.60	9.50	7.72

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Experiment 13.5: Identification of plant materials as natural anti-ferments for the collection of fresh toddy. Bandirippuwa Estate, Lunuwila (2001).

According to literature, coconut husk, cinnamon and vanillin powder could be used as preservatives for fresh toddy (Cocomunity Newsletter). Further, tender papaya has been tested to prevent natural fermentation of fresh toddy (personal communication). But the details of results have never been published. Therefore, the objective of this study was to determine the affectivity of these material and appropriate biochemical reasons.

The following plant materials were added to collection pots every day.

Treatments: (for approximately a liter of fresh toddy)

T1 – fresh coconut husk (50 g) + dried cinnamon bark (5 g)
T2 – dried coconut husk (25 g) + dried cinnamon bark (5 g)
T3 – fresh coconut husk (50 g)
T4 – dried coconut husk (25 g)
T5 – dried cinnamon bark (5 g)
T6 – hal bark (5 g)
T7 – tender papaya (50 g)
T8 – vanillin powder (0.2 g)
T9 – Control

The sugar content, pH and the alcohol percentage of the collected sap were measured. In the preliminary studies, tender papaya, fresh coconut husk and vanillin powder were identified as effective materials, in addition to hal bark. The study is being continued.

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Experiment 13.6: Effect of 'tapping stimulus' on the differentiation of female flowers in unopened coconut inflorescences. Bandirippuwa Estate, Lunuwila (1996).

In coconut, the formation of female and male flowers takes place 20 and 21 months respectively after initiation of the primordium. There is a belief that when a coconut palm is tapped for some time and allowed for nut production, there is an increase in the number of female flowers in the newly emerging inflorescence. Therefore, whether the 'tapping process' acts as a stimulant for female flower differentiation in successive spadices and, the duration taken to sense the stimulation were evaluated.

The following treatments were tested.

T1- Nut production

T2- Periodic nut and toddy production in alternate spadices (from Jan – Dec 2001)

T3- Continuous tapping for one year followed by nut production (tapping from April 99- May 2000)

Number of female flowers in newly emerging inflorescence was counted. Periodic tapping and nut production in alternate spadices for a period of one year did not increase the number of female flowers in nut producing inflorescence compared to control. When the palms were tapped for a period of one year and allowed to produce nuts, a higher number of female flowers were present in the inflorescence emerged 24 months after the commencement of tapping (from April 2001). This stimulatory effect was observed only for a period of eight months (Table 5).

Table 5 : *Number of female flowers in the nut producing bunches in 2001*

	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Nut production	25	20	19	18	19	24	24	22	23	24
Periodic nut and toddy	29	22	15	15	26	14	21	19	22	20
Continuous tapping for one year	24	30	29	33	36	35	36	32	29	18

Stimulation was present during this period

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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 bodiri (1999).

To refine the existing protocol for the quality preservation of tender nuts and enhance the acceptance of the product in overseas markets, experiments were commenced to select ;

(a) Most effective concentration of the new fungicide Benor to replace Benlate (not available in the market).
(b) Different wax treatments to improve shelf-life up to 2 months

T1	Paraffin wax + Oleic acid +Triethanol amine + Benor + water
T2	Micro wax + Oleic acid +Triethanol amine + Benor + water
T3	Carnauba wax + Oleic acid +Triethanol amine + Benor + water
T4	T1 + T2 + T3

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PROJECT B-17: WATER RELATIONS OF THE COCONUT PALM

Experiment B-17.2 : Importance of root to shoot communication in drying soil: role of abscisic acid in drought tolerance in coconut (1997).

An experiment was carried to determine the physiological performance of Tall x Tall, Tall x San Ramon and Dwarf Green x Tall seedlings and adult palms under plant house and field conditions, respectively at three different soil moisture regimes. The experiment was a Completely Randomize Block Design with 8 replicates per treatment. Three different soil water status were obtained by changing the frequency of watering in the plant house and according to rain-free period in the field.

Treatments:

Treatment	Water status	Plant house	Field
T1	Field Capacity (FC)	Watering everyday	Immediately after a rainy period
T2	Moderate Stress (MS)	Watering at 15 days intervals (MS)	25 days of rain free period
T3	Severe Stress (SS)	Watering at 20 days intervals (SS)	65 days of rain free period

The rates of photosynthesis (Ph), leaf water potential (Lw), transpiration (Tr), stomatal diffusive resistance (rs), relative water content (RWC) and water use efficiency (WUE) of seedlings and adult palms were measured.

The statistical analysis showed that there was no significant interaction between varieties and treatments indicating that they are independent of each other. However, under plant house conditions, there was a significant difference in Tr and WUE among the varieties. The highest rate of Tr was observed in DxT and it was significantly different from TxT and TxSR. The highest rate of Ph and WUE was observed in TSR (Table 6).

Table 6 : *Rates of photosynthesis ($\mu mol\ m^{-2}s^{-1}$), leaf water potential (bars), transpiration ($\mu g\ cm^{-2}\ s^{-1}$), stomatal diffusive resistance ($s\ cm^{-1}$), relative water content (%) and water use efficiency ($\mu mol\ g^{-1}$) of three varieties under plant house conditions.*

Variety	Ph	Lw	Tr	rs	RWC	WUE
TxT	3.65	-14.76	1.08^{b}	27.54	88.56	356.85^{ab}
TxSR	3.969	-14.10	1.01^{b}	26.85	88.11	406.80^{a}
DxT	3.30	-15.72	1.45^{a}	26.38	88.64	298.80^{b}
%CV	28.10	17.98	32.61	28.09	6.72	37.43
Sig.	ns	ns	***	ns	ns	*

There was a significant difference in Ph, Tr, rs and RWC between stressed and unstressed seedlings under plant house conditions. The rates of Ph, Tr and RWC were lower and the Lw and rs were higher in stressed seedlings compared with unstressed seedlings (Table 7).

Table 7 : *Rates of photosynthesis, leaf water potential, transpiration, stomatal diffusive resistance, relative water content and water use efficiency of coconut seedlings under three soil moisture regimes; field capacity (FC), moderate stress (MS), severe stress (SS) under plant house conditions.*

Water status	Ph	Lw	Tr	rs	RWC	WUE
FC	6.07^{a}	-11.16^{c}	2.13^{a}	13.74^{c}	93.42^{a}	313.16^{b}
MS	2.43^{b}	-17.98^{a}	0.81^{b}	27.31^{b}	87.06^{b}	333.32^{b}
SS	2.39^{b}	-15.44^{c}	0.61^{c}	39.71^{a}	84.83^{c}	415.97^{a}
%CV	28.10	17.98	32.61	28.09	6.72	37.43
Sig.	***	***	***	***	***	*

Under field conditions, the Lw, RWC and WUE of DxT palms, were significantly different from that of TxT and TxSR grown in the field. DxT showed the lowest Lw and the highest RWC and WUE. The highest rs and the lowest Lw have resulted the highest RWC in DxT palms. The highest rate of photosynthesis under plant house conditions was observed in TxSR. Under field conditions, DxT showed the highest rate of Ph, lowest rate of transpiration and, hence the highest WUE. There was no significant difference in rs among the varieties in the field. However, DxT showed the highest rs (Table 8).

Table 8. *Rates of photosynthesis ($\mu mol\ m^{-2}s^{-1}$), leaf water potential (bars), transpiration ($\mu g\ cm^{-2}\ s^{-1}$), stomatal diffusive resistance ($s\ cm^{-1}$), relative water content (%) and water use efficiency ($\mu mol\ g^{-1}$) of three varieties under field conditions.*

Type	Ph	Lw	Tr	rs	RWC	WUE
TT	2.89	-8.67[a]	1.08	30.24	95.99[a]	306.11[a]
TSR	3.09	-9.09[a]	1.10	30.81	96.14[a]	331.88[a]
DT	3.27	-7.94[b]	0.86	38.13	97.86[b]	583.65[b]
%CV	46.08	11.95	46.44	43.21	25.02	68.29
Sig.	ns	***	ns	ns	***	**

Except the RWC, all the other parameters showed a significant difference between stressed and non-stressed palms under field conditions. Moreover, there was a significant difference in Tr and rs among the three water regimes (Table 9).

Table 9. *Rates of photosynthesis, leaf water potential, transpiration, stomatal diffusive resistance, relative water content and water use efficiency of coconut seedlings under three soil moisture regimes; field capacity (FC), moderate stress (MS), severe stress (SS) under field conditions*

Water status	Ph	Lw	Tr	rs	RWC	WUE
FC	5.33a	-9.39a	1.03a	18.23a	96.71	342.87b
MS	1.57b	-8.89b	0.96b	30.70b	96.86	192.23a
SS	2.36b	-7.41b	0.45c	50.25c	96.43	686.54a
%CV	46.08	11.95	46.44	43.21	25.02	68.29
Sig.	***	***	***	***	ns	***

Physiological performance of the three varieties in the plant house under three soil moisture regimes was different to that in the field. Except the WUE, all the other parameters, Ph, Lw, Tr, rs, and RWC under plant house conditions were significantly different to that of the field. Lw, rs and RWC of adult palms grown in the field were higher than the seedlings grown in plant house, irrespective of soil moisture regimes and variety. The Ph and Tr of seedlings grown in the plant house were higher than the palms grown in the field (Table 10).

Table 10. *Rates of photosynthesis, leaf water potential, transpiration, stomatal diffusive resistance, relative water content and water use efficiency of coconut under plant house and field conditions.*

Type	Ph	Lw	Tr	rs	RWC	WUE
Plant house	3.64a	-14.86a	1.18a	26.92a	88.44a	354.15
Field	3.09b	-8.57b	1.01b	33.06b	96.66b	407.21
%CV	37.66	22.98	44.12	39.52	5.02	66.49
Sig.	*	***	*	**	***	ns

The abscisic acid (ABA) content of the three varieties in three soil moisture regimes, in the plant house and field, are being analyzed.

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Experiment B-17.4: Determination of the effect of different mulching material on plant water status in drought prone coconut lands. Ratmalagara Estate (1997).

Mulching the manure circle with coconut husks, coir dust, straw, black polythene or dried coconut fronds was not effective in improving the palm water status during dry periods of more than 60 days in Andigama soil series. All the treatment palms were equally sensitive to soil water depletion and responded to water deficit by increasing the stomatal resistance (Annual Report 1999). Among the treatments, black polythene mulched palms showed the highest water deficit condition during dry periods. Therefore, the objective of this study was to determine the effect of black polythene mulch on the soil temperature during dry periods. The variation in diurnal temperature at 15 and 30 cm depth of coir dust mulched and unmulched palms were measured against the black polythene mulched palms.

The treatments were;

T_1 - Control (no mulch)
T_2 - Black polythene mulch (400 gauge black polythene cover)
T_3 - Coir dust mulch (10 cm thick)

Soil temperature under black polythene mulch (15 cm and 30 cm depth) was 1.0-1.2 °C higher than an un-mulched palm and 2.0-2.3°C higher than a coir dust - mulched palm during dry periods (Table 11).

Table 11. *Diurnal soil temperature of unmulched (control), black polythene mulched and coir dust mulched palms.*

Treat	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00
Control	29.0[b]	29.8[b]	29.3[b]	29.2[b]	29.4[b]	29.6[b]	29.7[b]	30.1[b]	30.3[b]	30.6[b]	30.6[b]	30.7[b]
Black polythene	30.0[a]	31.0[a]	30.4[a]	30.3[a]	30.4[a]	30.6[a]	30.8[a]	31.1[a]	31.3[a]	31.6[a]	31.6[a]	31.7[a]
Coir dust	28.4[c]	28.5[c]	28.4[c]	28.4[c]	28.5[c]	28.6[c]	28.6[c]	28.8[c]	27.7[c]	29.0[c]	29.0[c]	29.0[c]
% CV	1.83	4.13	2.37	2.25	2.37	2.59	2.72	2.95	2.61	3.44	3.32	3.14
Sig.	***	***	***	***	***	***	***	***	***	***	***	***

Irrespective of the treatment the soil temperature at 15 cm depth was higher than that of 30 cm in the afternoon and evening (Table 12).

Table 12 : *Diurnal soil temperature at 15 cm and 30 cm depths.*

Treat.	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00
30 cm depth	29.4[a]	30.0	29.5	29.4	29.4	29.4[b]	29.4[b]	29.6[b]	29.7[b]	29.8[b]	29.9[b]	29.9[b]
15 cm depth	28.7[b]	29.6	29.2	29.3	29.5	29.8[a]	30.0[a]	30.4[a]	30.0[a]	31.0[a]	31.0[a]	30.9[a]
CV	1.83	4.13	2.37	2.25	2.37	2.59	2.72	2.95	2.61	3.44	3.32	3.14
Sig.	***	ns	ns	ns	ns	*	***	***	***	***	***	***

Experiment B-17.5: **Effect of different ground cover management systems on the growth of coconut palms in Andigama soil series at RE (1997).**

The effect of different ground cover management systems on the water status of coconut palms grown in shallow soils was studied. The following treatments were imposed:

T_1 - Dead mulch in the manure circle; rest of the land bare (MCDM/CSB)
T_2 - Dead mulch in the manure circle; rest of the land grass cover (*B. brizantha*) slashed every 6 months (MCDM/CSGC)
T_3 - Dead mulch in the manure circle; rest of the land uncontrolled grass cover (*B. briazantha*) (MCDM/CSGU)
T_4 - Dead mulch in the manure circle; rest of the land *Pueraria* cover (MCDM/CSP)
T_5 - Dead mulch in the manure circle; rest of the land 6" thick coir dust cover(MCDM/CSCD)

Dead mulch (DM): 12 coconut fronds without petioles / yr

Plant water relations were measured throughout the year at monthly intervals. During the wet periods, transpiration rate, stomatal diffusive resistance and leaf water potential were not affected by the ground cover. During the dry periods, the transpiration rate was higher, and stomatal diffusive resistance was lower in the palms with coir dust treatment (T_5, Table 13).

Table 13. *Effect of different ground cover treatments on rate of transpiration, stomatal diffusive resistance and leaf water potential of coconut palms during wet and dry periods of the year.*

	Rate of Transpiration ($\mu g\ cm^{-2}\ s^{-1}$)		Stomatal diffusive resistance ($s\ cm^{-1}$)		Leaf water potential (MPa)	
	Wet	Dry	Wet	Dry	Wet	Dry
T_1	2.306^{bc}	0.896^{b}	12.996^{ab}	34.08^{abc}	-1.08	-0.90^{bc}
T_2	3.834^{ab}	0.740^{b}	6.562^{bc}	48.27^{a}	-1.24	-1.08^{a}
T_3	2.656^{bc}	0.896^{b}	8.434^{bc}	36.67^{ab}	-1.21	-1.00^{abc}
T_4	1.946^{c}	0.894^{b}	16.396^{a}	36.83^{ab}	-1.07	-0.99^{abc}
T_5	3.074^{bc}	1.684^{a}	8.368^{bc}	22.01^{bc}	-1.20	-1.06^{ab}
Sig	**	**	**	**	ns	**
%CV	38.1	41.2	64.4	36.5	19.09	12.9

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Experiment B-17.6: **Screening coconut palms (*Cocos nucifera* L.) for drought tolerance using physiological, biochemical and molecular traits (2001).**

It is expected to screen available varieties, forms and accessions of coconut using possible physiological, biochemical and molecular tools with the objective to identify a suitable parameter/s to develop a procedure that can be applied for mass scale screening of drought tolerant palms. The expression of water stress-inducible

genes that have been identified in other crops will be tested on coconut using isolated m-RNA from leaves of water stressed coconut seedlings and adult palms.

Four coconut cultivators have been selected and allowed to establish in the plant house environment for the initial plant house experiment prior to the field-testing. The plant house experiment is a Randomized complete block design (RCBD) with 3 blocks, 4 coconut varieties (V_1 - Dwarf Green, V_2 – Ambakelle Special, V_3 – Dwarf Green x Tall, V_4 – San Ramon), 2 water treatments (T_1 – Field Capacity, T_2 – Drying by withholding water for 6 weeks) with 3 seedlings per plot giving a total of 72 seedlings. Treatments were randomly allocated for plots in each block considering both variety and the water treatment together as a treatment combination.

It is expected to collect leaf samples at the end of imposed drying period for the isolation of *m*-RNA for the testing of the expression of different genes applying the Northern blotting technique using *Hsp 70, Rab 16, Dhn 1* and *Sal t* as probes. In addition, the changes in vegetative growth, biochemical and physiological aspects accompanied by the water stress would be observed during and after the imposition of water stress. It is expected to test 12 coconut varieties and 25 coconut accessions at the next stage employing the same technique using fifteen-year-old adult palms in the field.

A Nainanayake

PROJECT : DEVELOPMENT OF THE NUT

Experiment B-: Development of the nut, embryo sac and the epidermal cells during fruit enlargement (2001).

The main objective of the study was to update the current knowledge on changes taking place during the nut development from female flower to mature nut. In each palm, two nuts from each bunch (from female flowers immediately after fertilization to mature nut) were harvested. Length, circumference and volume of the nut and embryo sac and, length and width of epidermal cells (using epidermal imprints of upper, middle and lower region of epicarp) of developing nuts were measured.

The following observations were made.

1. The elongation and expansion of the nut start immediately after fertilization and continue up to nine and eleven month stages, respectively, showing the highest rate of increase during fifth to ninth month period. The nut increases in volume up to eleven month showing the highest rate of increase during sixth to ninth month period.

2. The embryo sac could be seen two months after fertilization and it increased in length and width up to ninth and eleventh month stages, respectively. The volume of the sac increased up to tenth month showing the highest rate of increase during fifth to tenth month period.

3. Initially, the outer skin of the fertilized nut consists of large number of small, thin walled epidermal cells. The elongation and expansion of these cells start two months and five months, respectively after fertilization and continue up to nine months stage.

C S Ranasinghe, W S Madurapperuma, PS A de Saram, M Gunawardane

PROJECT 24: LEAF SCORCH DECLINE OF COCONUT PALM

Experiment 24.5: Investigations on leaf micronutrients of Leaf Scorch Decline (LSD) affected palms.

In LSD-affected palms, the leaf Zn content was lower than apparently healthy palms (CRI Ann Report, 1999). Therefore, the affected palms at Bandirippuwa and Walpita estates were root fed with 100 ml of 1% $ZnSO_4$ solution at bimonthly intervals for a period of one year to determine the effect of Zn on expression of LSD symptoms.

Variation in total number fronds, affected fronds in the canopy and % of leaf scorching in each affected frond were recorded at monthly intervals. The leaf Zn content in the treated and untreated palms was also analyzed at 3 monthly intervals.

The number of LSD-affected fronds was reduced after 1 yr but it was not significant (Table 14). The leaf Zn level was not improved five months after the treatment application (Table 15).

Table 14. *The no. of total and LSD-affected fronds in the canopy and the % of LSD spread in the leaves of healthy and LSD-affected (mild and moderate) palms at Walpita Estate. Pre-treat: before treatment application, Post-treat: after treatment application.*

	Total number of fronds		Number of affected fronds		% of LSD spread in the fronds	
	Pre-treat	Post-treat	Pre-treat	Post-treat	Pre-treat	Post-treat
Healthy	27	27	-	-	-	-
Mild	28	26	12	10	50%<	50%<
Moderate	25	24	12	10	50%>	50%>

Table 15 : *Concentration of leaf Zn in control and root-fed palms.*

	Healthy		Mild-LSD		Moderate-LSD	
	Control	Root- fed	Control	Root- fed	Control	Root- fed
Pre-treat.	17.36	17.25	11.89	9.28	12.44	11.86
Post-treat.- 2 months	17.67	19.15	12.03	11.23	12.45	12.59
Post-treat.- 5 months	16.49	18.36	11.91	11.58	12.26	13.43

W S Madurapperuma, C S Ranasinghe, R D N Premasiri, L R S Silva

5. TRAINING AND EXTENSION ACTIVITIES

Mr K R E M Fernando, Lab and Field Assistant of Coconut Research Institute completed a six-month research project on 'Encourage toddy tapping for better income' for the certificate course of National Institute of Plantation Management, Colombo, under the supervision of Dr C S Ranasinghe.

Research and technical staff participated as resource personnel in many training programs for Agriculture teachers and students, Agriculture extension officers and Coconut Development Officers.

7. STAFF PUBLICATIONS AND COMMUNICATIONS

b. Journals, presentations at seminars / workshops and scientific sessions

Nainanayake N P A D, Bandara D C, Ranasinghe C S (2001) The impact of soil type, soil compaction and water stress on above and below ground components of coconut (*Cocos nucifera* L.) seedlings. *Cocos* (in press)

Ranasinghe C S, Mathes D T, Silva L R S, Kularatne J D J S. (2001). A non-destructive method for determining leaf area of unsplit leaves of coconut seedlings. *Cocos* (in press).

Ranasinghe C S, Wijesekara R, Wimalasekara R. (2001) Rapid Decline Syndrome of Coconut (*Cocos nucifera* L.) – Preliminary report of a new condition. *Palms* (in press).

8. ACKNOWLEDGEMENT

The co-operation and assistance extended by the staff of the Plant Physiology Division in conducting experiments, data collection and in compiling this report is gratefully acknowledged. Sincere thanks are due to Head and staff of Biometry Division for the assistance in analysis of data.

MULTI-DISCIPLINARY PROJECTS
Project Coordinator – C S Ranasinghe, Ph D

PROJECT 17 : COCONUT RAPID DECLINE (CRD)

Divisions that participated:

Plant Physiology Division
Crop Protection Division
Soils and Plant Nutrition Division
Biometry Division
Genetics and Plant Nutrition Division
Survey group (Plant Physiology Division, Crop Protection Division)

General

A multidisciplinary research programme was started to determine possible causes, effect of different treatments, soil physical properties, physiology, anatomy and the pattern of seed germination of CRD-affected palms. With the financial assistance of Food and Agricultural Organization (FAO) the molecular studies were commenced to determine whether a phytoplasma, virus or viroid is associated with CRD. A general survey was conducted at Bandirippuwa Estate and Makandura Seed Garden to determine the occurrence and distribution of CRD. However, the causes and remedial measures of CRD are yet to be identified.

Experiment 1: Investigations to identify probable causes of CRD (MSG, 2000).

The experiment was continued at Makandura Seed Garden with the objective to find out the effect of different treatments on the progress of CRD symptoms. It was a Completely Randomized Block Design (RCBD) with 12 palms per treatment, and the application of treatments was started in August 2000.

The following treatments were applied.

T1- micronutrients (0.46 g $CuSO_4$ and 0.76 $ZnSO_4$ / palm, root feeding at bimonthly intervals)
T2 - common salt (1 kg / palm / year, surface application in the manure circle)
T3 - fungicide (Topsin 0.2% solution, 20 L / palm, drenching the manure circle at four monthly intervals)
T4 – nematicide (Nemacur 5% granules, 50 g / palm, surface application in the manure circle at four monthly intervals)
T5 – fungicide + nematicide (T3 + T4)
T6 – oxytetracycline (5g / 5ml / palm, trunk injection at four monthly intervals)
T7 – control (affected palms without treatment)

Data collection:

To assess the progress of symptoms the following data was collected.

1. Number of healthy, drooped and broken fronds in the canopy – at three monthly intervals
2. Nut numbers and weight, length and circumference of nuts - at two monthly intervals
3. Trunk circumference at canopy level - at six monthly intervals
4. Length and circumference of unopened spadix - at six monthly intervals
5. Leaf nutrient levels - at six monthly intervals
6. Chlorophyll content, stomatal resistance and transpiration of leaves - at three monthly intervals
7. Nematode and fungal populations in roots and adjacent soils - at three monthly intervals
8. Photographs of affected palms - at three monthly intervals

Canopy characteristics

A significant difference in the percentage of green-drooped fronds in the canopy was not observed among the treatments, three months and one year after initial treatment application. However, irrespective of the treatments percentage of green-drooped fronds was reduced in Aug 2001 compared to November 1999 possibly due to the prevailed drought in 2001 (Table. 1).

Table 1. *Percentage of green drooped fronds in CRD- affected palms in response to different treatments (three months and one year after initial treatment application).*

	Percentage (%) of green drooped fronds	
Treatments	Nov 00 (3 months)	Aug 01 (1 year)
Micro Nutrient	13.27	3.40
Common Salt	11.62	2.85
Topsin (Fungicide)	12.89	4.79
Nemacur (Nematicide)	12.02	7.74
Topsin + Nemacur	11.84	1.83
Oxytetracycline	13.48	6.59
Control	12.95	4.86
Significance	ns	ns

Nut and spadix characteristics

There were no significant differences in weight, length and circumference per nut and the number of nuts and female flowers per bunch among the treatments one year after the initial treatment application (Tables 2a and 2b).

Table 2a. *Weight, length and circumference of the nuts of CRD-affected palms in response to different treatments.*

Treatments	Nov 00 (3 months)			July 01 (1 year)		
	Weight/ Nut (Kg)	Nut length (cm)	Nut circumference (cm)	Weight/ Nut (Kg)	Nut length (cm)	Nut circumference (cm)
Micro Nutrient	1.59	NA	NA	1.36	21.61	36.59
Common Salt	0.86	NA	NA	1.82	25.48	42.76
Topsin (Fungicide)	0.97	NA	NA	1.34	23.48	39.34
Nemacur (Nematicide)	0.91	NA	NA	1.11	28.00	46.71
Topsin + Nemacur	0.92	NA	NA	0.99	25.77	43.18
Oxytetracycline	1.04	NA	NA	1.24	25.62	44.22
Control	1.10	NA	NA	1.48	29.55	49.28
Significance	ns			ns	ns	ns

Table 2b. *Number of nuts and total number of female flowers per bunch in CRD-affected palms in response to different treatments.*

Treatments	Nov 00 (3 months)		July 01 (1 year)	
	Number of nuts per bunch	Total number of female flowers produced per bunch	Number of nuts per bunch	Total number of female flowers produced per bunch
Micro Nutrient	6	NA	2	10
Common Salt	6	NA	4	13
Topsin (Fungicide)	6	NA	3	10
Nemacur (Nematicide)	6	NA	3	12
Topsin + Nemacur	5	NA	4	10
Oxytetracycline	5	NA	4	13
Control	9	NA	3	10
Significance	ns		ns	ns

NA: not applicable (data was not collected)

Furthermore, significant differences in length and circumference of unopened spadices were not observed among the treatments one year after the initial treatment application (Table 2c).

Table 2c. *Length and circumference of unopened spadices in CRD-affected palms in response to different treatments (after one year).*

Treatments	Spadix length (cm)	Spadix circumference (cm)
	Aug 01	Aug 01
Micro Nutrient	53.97	15.26
Common Salt	67.39	17.41
Topsin (Fungicide)	66.09	18.12
Nemacur (Nematicide)	52.70	15.29
Topsin + Nemacur	54.53	14.58
Oxytetracycline	66.78	15.80
Control	64.98	17.49
Significance	ns	ns

Trunk characteristics

Significant differences in circumference of trunks at the canopy level and 1' below the canopy level were not observed among the treatments one year after initial treatment application (Table 3).

Table 3. *Trunk circumference (at canopy level and 1' below) of CRD-affected palms in response to different treatments (after one year).*

Treatments	Trunk circumference at the canopy level (cm)	Trunk circumference 1' below the canopy level (cm)
	Aug 01	Aug 01
Micro Nutrient	62.42	65.88
Common Salt	68.32	66.78
Topsin (Fungicide)	66.94	66.65
Nemacur (Nematicide)	63.66	65.32
Topsin + Nemacur	63.76	64.66
Oxytetracycline	64.08	64.90
Control	63.45	65.77
Significance	ns	ns

Physiological and biochemical characters

No significant difference in the chlorophyll content was observed among the treatments three month and one year after initial treatment application (Table 4a).

There were significant variations in the rate of leaf-transpiration and stomatal diffusive resistance among the treatments. However, the rate of transpiration between treated and untreated (control) palms was not significantly different one year after the treatment application (Table 4b). The stomatal diffusive resistance of CRD-affected palms treated with common salt, micronutrients and nematicide treatments was lower than untreated palms one year after the initial treatment application (Table 4b).

Table 4a. *Total Chlorophyll content (mg/g fresh weight) of CRD-affected palms in response to different treatments ((after three months and one year)*

Treatments	Nov. 00 (3 months)	April 01 (1 year)
Micro Nutrient	2.03	2.67
Common Salt	2.28	2.59
Topsin (Fungicide)	2.20	2.66
Nemacur (Nematicide)	1.90	2.92
Topsin + Nemacur	2.23	2.83
Oxytetracycline	2.15	2.65
Control	2.22	2.86
Significance	ns	ns

Table 4b. *Rate of transpiration (µg cm $^{-2}$ s^{-1}) and stomatal diffusive resistance (s cm^{-1}) of CRD-affected palms in response to different treatments*

	Rate of transpiration		*Stomatal diffusive resistance*	
Treatments	Nov 00 (3 months)	Aug 01 (1 year)	Nov 00 (3 months)	Aug 01 (1 year)
Micro Nutrient	1.84 ^{abc}	0.56 ^{ab}	22.96 ^{ab}	67.76 ^{c}
Common Salt	1.94 ^{ab}	0.61 ^{a}	12.14 ^{c}	66.17 ^{c}
Topsin (Fungicide)	2.00 ^{ab}	0.43 ^{bc}	19.08 ^{abc}	79.89 ^{abc}
Nemacur (Nematicide)	1.39 ^{bc}	0.50 ^{abc}	25.87 ^{a}	73.58 ^{bc}
Topsin + Nemacur	1.20 ^{c}	0.40 ^{c}	24.68 ^{ab}	91.42 ^{a}
Oxytetracycline	1.90 ^{ab}	0.44 ^{bc}	15.92 ^{bc}	86.64 ^{ab}
Control	2.34 ^{a}	0.49 ^{abc}	13.70 ^{c}	96.06 ^{a}
Significance	*	*	*	**

Nematode population in soil and roots and *Fusarium* colonies in the roots

The data collection on the above parameters was carried out for the following treatments.

T3- Topsin (Fungicide)
T4- Nemacor (Nematicide)
T5- Nemacor+Topsin
T6- Control

Soil and root samples were obtained at 3 monthly intervals. Number of parasitic nematodes in 250cm^3 of soil and 25g of roots was recorded.

Parasitic nematodes were present in every soil sample collected during the period of June-December 2001 and root samples collected in December 2001. However, both in soils and roots, treatment effects on the nematode population were not observed instead, there was a clear variation in nematode population with the season (Figs 1 and 2)..

Fig 1: Parasitic nematodes in soils over months

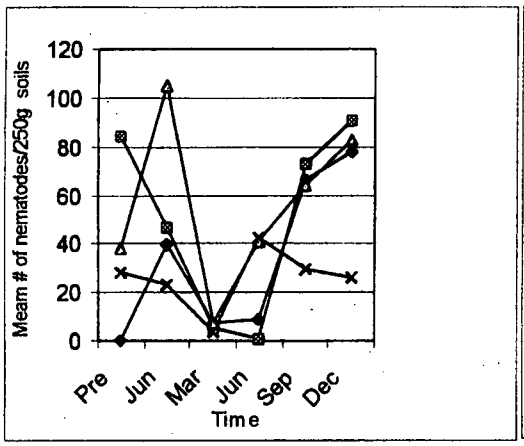
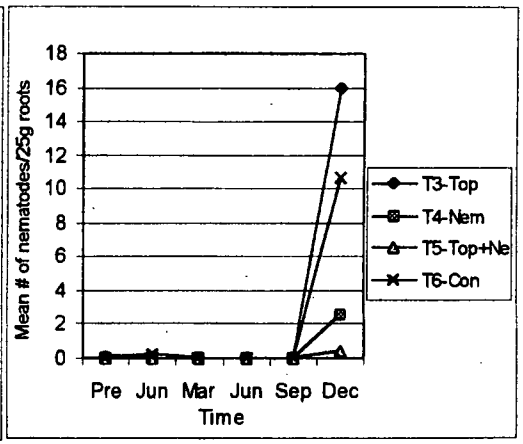


Fig 2: Parasitic nematodes in roots



One year after the initial treatment applications, significant improvements in the CRD-affected palms were not obtained. The treatment application and data collection are in progress. It seems that it is too early to see any treatment effect on the symptom expression in CRD-affected palms.

A Wijeratne, C S Ranasinghe, R Wijesekara, D T Mathes, D Giritharan, D M D I Wijebandara, R D N Premasiri, L R S Silva, C Hapuarachchi, S P Manoj, P H A P Siriwardane, R Jayatillake, S S Rajapakse, N G Pemasiri, W W F N Fernando, R Silva

Experiment 7: Investigation of causative agent of CRD using molecular diagnostic techniques

The project is funded by the Food and Agricultural Organization (FAO). Main objective of this study was to determine whether a phytoplasma, virus or viroid is associated with CRD. The presence of phytoplasmas in CRD affected palms were tested using nested polymerase chain reaction (PCR) approach using two sets of published general universal histoplasma primers, one pair internal to the other pair, which amplifies the ribosomal gene sequence of phytoplasmas. A histoplasma specific signal was obtained for primers P1/P7 and LY16Sf/LY1623r and primers P1/P7 and R16F2n/R16R2 from total nucleic acids extracted from coconut trunk shavings from only one out of 10 'diseased' palms analysed, but not from any of the 10 healthy palms tested. This same palm was further analysed using 30 more DNA extracts from trunk shavings sampled from top to the bottom of the palm and five of

them were observed as positive. The PCR product was sequenced and the sequence showed greatest sequence similarity to 16S rRNA gene of various infecting phytoplasma sequences including Bermuda grass white leaf phytoplasma 16S ribosomal RNA gene (96% homology) and Peach rosette phytoplasma 16S ribosomal RNA gene (94% homology). However continuation of the work so far did not give positive signals not only from any of the other 'diseased' palms analyzed but also from the previously positive 'diseased' palm. Analysis of sufficient number of affected as well as healthy palms and samples from various tissues including symptomatic tissues and symptomless tissues in different seasons seems to be necessary before confirming or eliminating a phytoplasma hypothesis in CRD affected palms. Continuation of the work is therefore in progress using different parts of the palm (e.g. roots, root tips, heart tissues etc.) as sources of phytoplasma, in addition to trunk shavings coupled with several different PCR primer combinations in the nested PCR.

L Perera, C S Ranasinghe, R Wijesekara, R W Randles (University of Adelaide, Australia)

Survey on occurrence and distribution:

The distribution of affected palms is mapped through observations at six monthly intervals to determine the pattern of spread at Makandura Seed Garden (MSG) and Bandirippuwa Estate (BE) of the Coconut Research Institute. According to the latest survey done in March 2001, there has been an increase in incidence on these estates (Table 5).

Table 7. *Occurrence of CRD- affected palms in Bandirippuwa Estate (BE) and in Makandura Seed Garden (MSG) during March / May2001.*

Estate	Total No of palms	% Affected	New additions during the last 6 months period
BE	171	3.18%	110
MSG	568	5.55%	288

R Wijesekara, A Wijeratne, R D N Premasiri, C Hapuarachchi, S P Manoj

REPORT OF THE EXTENSION SERVICES DIVISION
Head – P A H Nimal Appuhamy, M Sc.

1. GENERAL

During the year, the Division involved in various activities and programmes to improve the technical knowledge and skills of coconut growers and extension personnel in order to promote the transfer of technology in the coconut sector.

Some activities focused mainly on the needs and constraints of coconut growers, who require technical advice, guidance and information to uplift the productivity of their lands. Successful implementation of whole farm development through Persuasive Extension Programme, improvement of technical capability of coconut growers in the form of one-day training series and training youths, as estate managers were major achievements during the year.

Further these programmes helped to promote linkages among research, extension and coconut grower, which is vital in the development of appropriate technologies for the coconut sector.

2. OTHER ACTIVITIES

Mr G R A Darmasena, Technical Assistant was transferred to the Extension Services Division from the Coconut Processing Research Division with effect from 01 February.

Mr. P K Sevvanthinathan was appointed as the Translater (Tamil/ English) Cum Editing Assistant on one year contract basis with effect from 05 February.

Mr. K H R L Appuhamy, Senior Office Attendant, retired from his service with effect from 02 March.

Mr. P A H Nimal Appuhamy, Head, Extension Services Division, has been assigned to cover the duties of the Librarian with effect from 01 May 2001.

Mr. P A H Nimal Appuhamy, Head, Extension Services Division, attended First Regional Workshop on the Performance Based Management Systems held at the Asian Institute of Management, Manila from 09 to 12 July.

Mr. C S Herath, assumed duties as Extension Officer of this Division with effect from 02 November. He is assigned with the responsibilities of using mass media for technology transfer and publicity activities.

3. PERSUASIVE EXTENSION PROGRAMME (PEP)

The Persuasive Extension Programme conducted with the objective of persuading coconut growers to adopt new technology in order to increase the productivity of their lands gained popularity. But estate visits had to be limited due to financial constraints. However, during the year under review, this service was

provided to 48 estates covering an extent of 2100 ac. Monitoring visits were also conducted to assess the progress of implementation of proposed estate development activities in previous years. During the year, 25 estate activities were monitored and found that land owners have implemented 60% of the proposed development activities.

4. TRAINING PROGRAMMES

4.1 One Day Training Programme series

The one-day training programme is designed to meet the training needs of coconut growers. In the recent past, the number of growers, who sought technical information to improve their knowledge and skills, has shown a significant increase. Seven one day programmes were conducted covering different technical aspect of coconut cultivation and estate management. Booklets prepared giving full details on the relevant subjects were issued to participants in each programme.

Details of one-day training programmes conducted during the year are give below.

Programme No	Date	Venue	Subject Area	No of Participants
01	27 April	Bandirippuwa Estate	Replanting of coconut & management of seedlings	100
02	18 May	Ratmalagara Estate	Soil and moisture conservation and irrigation	90
03	20 July	Bandirippuwa Estate	Inorganic and organic fertilizer application	116
04	17 August	Walpita Estate	Intercropping under coconut	100
05	21 Sept	Bandirippuwa Estate	Pests and diseases of coconut	100
06	19 Oct	Ratmalagara Estate	Rehabilitation of low yielding coconut estates	93
07	16 Nov	Bandirippuwa Estate	Coconut estate management and record keeping	69

A certificate was given at the end of the year to those who participated the whole series of training.

4.2 Estate Managers Training Programme

A survey conducted by the Coconut Research Institute revealed, that productivity level of medium and large estates was poor due to various management problems. Majority of these land owners, being absentee landlords face enormous difficulties in implementing improved management practices which are essential to uplift the estate productivity. Absentee landlords are forced to entrust estate development activities to the estate watchmen who is not educated and knowledgably enough to implement these such resulting in poor return for investments. Unavailability of trained and educated people to be recruited to manage estates of such landowners could be seen as a serious shortcoming in the sector. The Institute observed that this situation as a major obstacle in technology transfer and technology adoption process.

To fulfill this need, the Institute commenced an intensive residential practical training for a batch of 25 youths with GCE (A/L) qualifications, as estate managers. Their first month training on technical aspects was conducted at CRI from 22 October to 23 November. Then they were divided into four groups and sent to Isolated Seed Garden, Ambakele, Pallama Seed Garden, Rathmalagara Estate and Walpita Estate for residential practical training on rotational basis under the supervision of superintendents and the CRI staff from 26 November to 11 January 2002. A certificate will be given to those who reach the expected level of technical competency. In response to the publicity given regarding this training, many landowners have already made inquires to recruit them as estate manager after their successful completion of training in late January 2002.

4.3 Other Training Programmes

4.3.1 Training programme on coconut nursery techniques for 10 officers from Pulgaswewa Estate, Rajakadaluwa on 07 June.

4.3.2 Two day training for 19 Regional Managers, Assistant Regional Managers of CCB on fertilizer recommendation based on DFR and pest control of coconut on 13 and 14 September.

4.3.3 A training was conducted for 24 trainees from NIPM for their National Diploma in Plantation Extension Management, Module on coconut production and processing, from14 to 19 March.

4.3.4 Tenth National Diploma in Plantation Management, Module 10 on coconut was conducted at CRI for 20 trainees from 30 July to 03 August.

4.3.5 One day training for a group of 40 NDT agriculture students from the Advanced Technical Institute, Naiwala on 12 October.

5 SEMINARS, FIELD DAYS, WORKSHOPS AND EDUCATIONAL PROGRMMES

5.1 Seminars

5.1.1. A seminar was conducted for coconut growers from the Coconut Growers Association of Sri Lanka at Bandirippuwa Estate on mechanization of coconut estate activities.

5.1.2. A seminar was conducted by Mr. P A H Nimal Appuhamy on Research Extension Linkage in Technology Development for the Coconut Sector on 29 August.

5.2.3. A seminar was conducted for a group of agriculture officials including 16 divisional secretaries from Kalutara District was conducted at CRI on 24 May.

5.2 Field Days

5.2.1 A field day was conducted for 85 coconut growers on rehabilitation of low yielding coconut estates on the request of the Coconut Growers Association of Sri Lanka on 09 November.

5.3 Workshops

5.3.1. A full day workshop on Coconut Cultivation with New Technology was conducted on 25 September for coconut growers. A Baur and Co Ltd sponsored this programme with the coordination of the International Lions Club Division.

5.4 Educational Programmes

5.4.1 A three months educational programme was conducted for a trainee from the school of agriculture, Palwehera from 02 March.

5.4.2 A four month educational progamme was conducted for two trainees from the National Apprentice and Industrial Training Authority from 02 May to 02 September.

5.4.3. A full day educational programme was conducted for a group of 45 agriculture diploma students from the Aquinas College on 02 March.

5.4.4 Educational programmes were organized for newly recruited field officers at CRI from 02 to 15 March.

5.4.5. A full day educational programme was conducted for a group of 35 diploma students from the School of Agriculture, Anuradhapura on 23 February.

5.4.6 An educational programme was conducted for a group of foreign and local group of youths visited CRI on the Canada and Sri Lanka youth exchange programme on 05 January.

5.4.7. A full day educational progamme was conducted for a group of 45 Agricultural Research and Production Assistant from Bandaragama Agrarian Center on 18 October.

5.4.8 An educational programme also conducted for a group of undergraduates from the University of Wayamba on 11 December.

6. EDUCATIONAL PROGRAMMES FOR SCHOOL CHILDREN

6.1 The Division conducted special educational programmes for students who visited the Institute in order collect necessary information for their GCE Ordinary Level or Advanced Level projects under the new educational reforms. During the year 56 educational programmes were conducted for the benefit of these students.

6.2 During the year, 4800 school children visited the Institute for their education purposes. Special educational programmes were conducted for these students to improve their knowledge on coconut cultivation and other important information about the sector.

7. ADVISORY ACTIVITIES

The number of visitors to the Division, who sought technical advice and guidance in respect of their field problems, has shown a significant increase during the year. Prompt attention was given to fulfill the needs of stakeholders who visited the Institute for their needs. The Division received nearly 200 visitors from different parts of the country to get assistance for their various needs, during the year.

Letters received from coconut growers, entrepreneurs and students requesting technical advice and information were promptly replied. During the year, nearly 150 such letters were replied. For those who request technical information in relation to recommended management practices, nearly 950 sets of Advisory Circulars were issued during the year.

8. PRINTING SECTION

The printing section of the Division. meet the major printing requirements of the Institute. Printing section undertook 89 printing jobs including printing and binding of books, journals, leaflets, forms and circulars.

9. PUBLICATIONS

During the year the following publications were issued

1. Two issues of CRI Newsletters were published and distributed to CCB staff and register growers.

2. Seven booklets were published in Sinhala on Replanting of Coconut, Soil Moisture Conservation, Fertilizer use, Intercropping under coconut, Pests and Diseases and Rehabilitation of low yielding coconut estates.

3. Eight advisory circulars were revised, printed and issued and 20 more circulars were reprinted.

4. CRI Annual Report 1999

5. A booklet on copra manufacturing

10. EXHIBITIONS

The Division participated in the following exhibitions.

1. "Nenasara 2001" exhibition at Sri Chandrajothi Vidyalaya from 05 to 11 April to generate funds for S W R D Bandaranayke Memorial Library and Cultural Centre.

2. Science exhibition at Vidya Mandiraya from 20 to 22 June in conjunction with the Annual Session of the Institute of Chemistry.

3. Educational exhibition held at Madya Maha Vidyalaya, Madampe from 29 to 30 July.

11. AUDIO VISUAL AND MUSEUM

Audiovisual facilities were improved in different ways to provide quality visual materials and services for seminars, field days, workshops and other public events.

CRI museum was renovated during the year. Exhibits of the museum were rearranged by adding new colourful display boards to improve the learning facilities of users.

REPORT OF THE LIBRARY
Actg. Librarian – P A H Nimal Appuhamy, M Sc.

1. GENERAL

The library extended regular and satisfactory services to its clients throughout the year. Information needs were satisfactorily extended to outside clients on request. The number of literature searches made by users both on coconut and CD-ROM databases.

The Librarian, Mrs. P A S F Perera and Asst. Librarian, Mr. R M Gunasekera, resigned from the service with effect from 30 March and 30 April respectively. Mrs. P D U C Dharmapala was promoted to the post of Assistant Librarian with effect from 03 September.

2. ACQUISITIONS

2.1 Collection of books

The number of printed books added to the collection was 43. Two (02) books were received from the ADB Project. Accordingly, the total stock recorded 5622 books as at 31 December, 2001.

2.2 Serials

The total number of serial titles received during the year was 37. Seven (7) titles were received on subscription and the others were received either on complimentary basis or exchange. To avoid delays in the receipt of issues renewed subscription for 12 titles for 2002 in advance during this year. Hence, the full allocation for the books and periodicals used to renew the 2002 subscription renewal.

2.3 Special collection on coconut

Literature collection on coconut showed slight progress over the previous year. The main constraint in acquiring material was the very limited financial resources. Lack of trained staff was another factor for this.

3. SERVICES

3.1 Literature searches

In addition to the quick reference queries made by the staff, 22 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 while 08 were made for outsiders.

Twenty five people visited the library during the year for information purposes.

3.2 Database development

109 new entries were added to the coconut database. It recorded a total 3499 entries as at 31 December.

3.3 External Services

Resource sharing activities were continued satisfactorily with other AGRINET libraries throughout the year.

SDCP Service

Selective Dissemination of Contents Pages (SDCP) for serials continued to be a major resource sharing activity provided at personalized level. Under this service contents pages of 170 journals received from outside libraries were supplied to staff members. The library supplied contents pages of 68 journals to other libraries under the same service.

Interlibrary loan service

The library received request for the supply 72 articles from which 56 were supplied. From 45 articles requested from outside libraries on behalf of the staff, only 34 were received. Certain items not available within the country were acquired from British Library, UK.

Publications

The "Current Awareness Bulletin" on literature on coconut were distributed among the research staff and a few selected outside libraries.

A bibliography was prepared on coconut oil and heart disease.

An annotated bibliography was prepared covering reference to literature during the period 1995.

Meetings and Workshops

Mrs. A P Illangakoon attended the Course on Library Automation from February to September at Sri Lanka Library Association.

REPORT OF THE ESTATE MANAGEMENT DIVISION
Manager (Estates): Mr.Frank Jayasinghe BSc

1. Summary

The Division administrated the following Estates and Seed Gardens-

1. Bandirippuwa Estate, Lunuwila
2. Ratmalagara Estate, Panirendawa
3. Pottukulama Estate, Pallama
4. Pallama Seed Garden, Pallama
5. Walpita Estate, Walpita
6. Isolated Seed Garden, Ambakelle
7. Makandura Seed Garden, Gonawila
8. Maduruoya Seed Garden, Bogaswewa
9. Dunkannwa Estate, Nattandiya

All units were maintained in good order. The recommended cultural practices were carried out and profitability of these properties was satisfactory. Out of the four Seed Gardens, seed nuts were issued for nurseries from Ambakelle and Maduruoya Seed Gardens. Issue of seed nuts from Makandura Seed Garden was further suspended due to rapid decline syndrome. The Pallama Seed Garden was under development and in replanting stage. The Coconut Development Authority (CDA) handed over the Dunkannawa Estate of 10 ha in extent to CRI on 30 years long-term lease.

Total yield of coconut in all eight Estates was 5,591,431 nuts, which was an increase of 3% over the pervious year and 36% above the average of the last 05 years (Table 1). This increase of yield could be mainly attributed to the soil water conservation and adoption of improved cultural practices even in the absence of well-distributed rainfall, compared to the previous year. Increase in the number of bearing palms may be another reason.

Despite this overall yield increase, Bandirippuwa Pottukulama,Makandura and Walpita Estates recorded a yield decline compared to previous year, due to the severe drought experienced in many parts of the country during the 2nd and 3rd quarters of this year.

The total rainfall received at Banirippuwa, Ratmalagara,Pottukulama, Isolated Seed Garden and Pallama Seed Garden was less than the 1500 mm during the year 2001 was very much lower than the previous year and also it was not well

distributed (Table2). Maduruoya Seed Garden received higher rainfall than previous year.

Out of the total coconut extent of 793.34 ha, palms in 160.16 ha in immature stage (Table 4). The nine Estates have a total of 74,059 bearing palms, 4391 partially bearing palms and 14017 of young palms and seedlings.

Replanting programme was carried out at Bandirippuwa Estate, Maduruoya Seed Garden and at Pallama Seed Garden. Establishment of 2829 hand pollinated seedlings of San Raman and Tall x Tall was carried out by the Genetics and Plant Breeding Division at Pallma Seed Garden.

During the year 1,278,343 seed nuts were produced in the two Seed Gardens and plus palms from the other estates Pottukulama, Pallama and Ratmalagara (Table 7) Of the total seed nut production, over 95% was issued to the Coconut Cultivation Board Nurseries.

The application of inorganic fertilizer was suspended for 50% the palms due to the shortage of funds. Also the application of organic fertilizer was not possible due to the lack of funds in all Estates except Makandura and Walpita Estates.

The Division received 05 Rotary slashers and 8 disc harrows during the year to fulfil the farm machinery requirements of Estates. A total length of 4110 metres of new fencing at Bandirippuwa, Pallama Seed Garden and Maduruoya Seed Garden was completed. Roads and Buildings were maintained satisfactorily.

The Estates sundry income and income from livestock sector increased up to Rs. 2,020,642 (Table 8). Coconut production of the six estates was disposed through the auction conducted by the Coconut Development Authority (CDA) mainly as husked nuts. The buyers rejection were converted into copra and sold by calling tenders from registered buyers (Table 6).

2. PERFORMANCE OF INDIVIDUAL UNITS.

2.1	**Bandirippuwa Estate**	:	**Lunuwila**
	Superintendent	:	**Mr.Santha Hettiarachchi**
	District	:	**Puttlam**
	Agro Climate Zone	:	**Intermediate wet Zone**
	Extent	:	**148.1 ha**

Rainfall:

Total rainfall received at Bandirippuwa was 1055 mm given is Table – 2. It shows a decrease of rainfall by 37% and wet days by 23% when compared to the last year. The rainfall distribution was very poor.

Nut Yield:

Nut yield decreased by 0.8% over the last year (Table - 1).

Planting:

484 (T x SR) coconut seedlings were planted in field No.7.

Fencing:

685 meters of new boundary fencing was completed at 35 Ac Block.

Livestock:

Herd strength by the end of this year was as follows.

Stud Bull	- 01
Heifers	- 34
Milking Cows	- 39
Male calves	- 62
	141

Milk Production and Sale:

Total milk production	-	7560 liters
Total income from milk	-	Rs. 83476. 00

Milk production decreased due to dry weather.

Other Production activities:

For toddy tapping and for production of sweet toddy 129 coconut palms were used. During the year, Rs.458313.00 was earned as total sundry income by selling fruit, vegetable and treacle etc (Table 8).

Cost of production and nut sale average:

COP was Rs. 6067 and N.S.A was Rs. 5812/- per 1000 nuts. (Table 6)

2.2. Ratmalagara Estate , Panirendawa

Superintendent	:	**Mr.A.N.Eknaligoda**
District	:	**Puttalam SP**
Agro climate zone	:	**Intermediate Dry Zone**
Extent	:	**110.48 ha**

Rainfall:

Total rainfall received was 1311 mm as given in Table 2. There was a decrease of rainfall by 22% and wet days by 6% compare to the last year. However the available rainfall was well distributed.

Nuts Yield:

Nut yield showed an increase of 15.5% (Table 1) over the last year.

Livestock:

Cart Bull	-	01
Cows	-	21
Heifer	-	26
Bull Calves	-	08
		56

Artificial insemination was successfully carried out and 19 improved calves were produced.

Sundry Income:

Income received from sale of vegetable, milk and other products was Rs.29373/- . (Table – 08).

Cost of production and nut sale average:

COP was Rs.4780/- and NSA Rs.7256/- per 1000 Nuts (Table 06).

2.3 Pottukulama Research Station

Superintendent	:	**Mr. G.B.A.Wijesekara**
District	:	**Puttalam SP**
Agro Economical Zone	:	**Intermediate Dry Zone**
Extent	:	**81.78 ha**

Rainfall:

Total rainfall and wet days recorded are given in Table 2. There was no decrease in rainfall. The number of wet days increased by 17% compared to the previous year. A well distributed rainfall was received during the year (Table 2).

Nut Yield:

The total nut yield is given in Table 1. There was a 6% decrease of yield over the last year.

Livestock:

The herd strength by the end of the year was as follows.

Cows	-	07
Heifers	-	18
Stud Bull	-	03
Buffalo	-	01
Goat	-	83 (Male 15 and Female 68)
Total	-	112

Sundry Income:

Total sundry income received from food production, milk and sale of animals etc was Rs.35511.11 (Table 8)

Cost of Production and nut sale average:

COP was Rs.3039/- and NSA was Rs.6767.00 per 1000 nuts.

2.4 Pallama Seed Garden

Superintendent	-	**Mr.W.S.M.A.Fernando**
District	-	**Kurunagala**
Agro Climate Zone	-	**Intermediate Dry Zone**
Extent	-	**252.0 ha**

Rainfall:

Rainfall and wet days are given in Table 2. The rainfall decreased by 6% and wet days increased by 7%. A well distributed rainfall was received throughout the year (Table 02).

Nut Yield:

Nut Yield increased by 6% during last year (Table 1).

Replanting:

A total of 2829 hand pollinated 2829 seedlings of San Ramon and Tall x Tall were planted by Genetics and Plant Breeding Division as guard rows and to fill vacancies in the seed garden. The forest barrier was established by planting various forest species such as Kumbuk, Jak, Kohomba and Accasia.

Irrigation:

During the drought period, all seedlings were irrigated once a week by using water boucers.

Fencing:

New fencing for 1730 meters was completed along the perimeter of the Estate.

Buildings/electricity:

Superintendent Bungalow was renovated and the construction of labour rest room, tractor shed and water tank were completed. The electricity supply was partially completed.

Sundry Income:

Rs. 615150.00 was received as sundry income by selling mature coconut palms, forest trees, etc.

Cost of Production and nut sale Average:

COP was Rs.6271.00 and NSA was 6600.00 per 1000 nuts.

2.5 Isolated Seed Garden, Ambakelle.

Superintendent	:	**Mr.W.B.A.Weragoda**
District	:	**Puttlam**
Agro Climatic Zone	:	**Intermediate Dry Zone**
Extent	:	**457.2 ha**

Rain fall :

For the rainfall and wet days please refer (Table 2) The rainfall decreased by 35% and the number of wet days increased by 4% over the last year. The rainfall distribution was very poor during this Year.

Nut Yield:

Nut yield increased by 5% compared to the previous year (Table 1).

Disposal of Crops:

About 75% of the crop was issued as seed nuts to the Coconut Cultivation Board, and a part was sold to Dunagaha Co. Society and the balance was cured into Copra (Table – 7).

Livestock :

		Female	Male
Cows	(Buffaloes)	11	-
Calves	(Buffaloes)	-	05
Heifers	(Buffaloes)	06	-
Stud Bull	(Buffaloes)	-	01
Cart Bull	-	-	01

Total Number of Animals = 24

Sundry Income:

Rs. 413823.00 was received as sundry income by sale of Curd, Animal and by leasing Cashew trees.

Cost of Production and nut sale Average:

The COP was Rs 3946.00 and the NSA was Rs. 7112.00 per 1000 nuts.

2.6 Makandura Estate

Superintendent : **Mr.I.A.Nimal Hemasiri**

District : **Kurunagala**

Agro Climatic Zone : **Intermediate Wet Zone**

Extent : **58.20 ha**

Makandrua Seed Garden was re-named as Makandura Estate as seed nuts issue has been suspended since the rapid decline syndrome in the palms was observed.

Rainfall:

Rainfall and the number of wet days are given in Table 2. There was a decrease in the total rainfall as well as number of wet days compared to previous year. The rainfall distribution throughout the year was very poor.

Nut Yield :

Nut yield has decreased by compared to the previous year (Table 1).

Livestock :

	Neat Cattle	Buffalos
Cows	07	07
Heifers	06	11
Stud Bull	02	01
Calves	04	04
	19	23

Sundry Income :

Rs. 45467.75 was received as sundry income by sale of curd, milk, banana etc (Table 8).

Cost of production and nut sale average:

The COP was Rs 3140.00 and the NSA was Rs. 7007.00 per 1000 nuts (Table 6).

2.7 Maduruoya Seed Garden

Superintendent	:	**Mr.W.M.U.Ratnayaka**
District	:	**Polonnaruwa**
Agro Climatic Zone	:	**Dry Zone**
Extent	:	**85 ha**

Rainfall:

Rainfall and number of wet days are given in Table 2. The total annual rainfall increased by 18% and the number of wet days decreased by 13% compared to the previous year. The distribution of rainfall throughout the year was very poor.

Nut Yield:

Nut yield increased by 16% compared to the previous year (Table 1).

Disposal of Crops:

About 70% of the nuts were issued as seed nuts to the Coconut Cultivation Board. The rejected nuts were sold to out side buyers (Table 7).

Irrigation:

The existing canal irrigation system was operated to provide sufficient water for palms during the dry season.

Building:

A vehicle shed, a labour rest room, and a toilet were constructed during the year.

Sundry Income:

Rs. 5758.00 were received as sundry income by sale of forest trees and vegetable etc.

Cost of production and nut sale average:

The COP was Rs 5742.00 and the NSA was Rs. 7697.00 per 1000 nuts.

2.8 Walpita Estate

Officer In Charge	:	**Mr.W.A.Harold Upali**
District	:	**Gampaha**
Agro Climatic Zone	:	**Wet Zone**
Extent	:	**17.8 ha**

Rain fall :

Rainfall decreased by 25% and wet days by 4% compared to the previous year (Table 2).

Nut Yield:

The annual nut yield decreased by 15% compared to the previous year (Table 1).

Sundry Income:

Rs. 152775.00 was received as sundry income by sale of pepper, cinnamon, coffee, pineapple and etc.

Cost of production and nut sale average:

The COP was Rs 5796.00 and the NSA Rs. 7196.00 per 1000 nuts (Table 6).

Routine agronomic practices carried out in estates

I. **Weed control**:

Weed control was done at a satisfactory level in all estates by manual, chemical and mechanical weed control methods and by animal grazing.

II. **Fertilizer Application**:

Fertilizer application was done according to DFR recommendation during Yala Season. Due to shortage of funds, the Maha Season fertilizer application program was suspended.

III. Moisture Conservation:

Moisture conservation was carried out in a satisfactory manner in all estates, by mulching palms with coconut husks, and coconut fronts and establishing covers crops.

IV. Picking:

Manual pickers in all estates did picking by monthly basis except Walpita Estate, where monthly picking was done.

Table 1. *Total Nut Production (1997 – 2001) and percentage increase in 2001 production over 2000*

Estate	1997	1998	1999	2000	2001	%
Bandirippuwa Estate	475,658	479,820	556,185	758,487	752,452	(- 0.8%)
Ambakelle Seed Garden	980,544	1,213,893	1,473,458	1,396,565	1,475,761	05.7 %
Poththukulama Estate	506,555	680,984	816,737	834,061	777,906	(-06.7%)
Ratmalagara Estate	402,626	445,928	526,947	658,968	760,946	15.5%
Pallama Seed Garden	-	441,376	592,661	640,343	680,946	06.3%
Makandura Seed Garden	389,484	356,399	451,152	644,016	636,889	(-01.4%)
Maduruoya Seed Garden	149,803	158,994	210,234	297,328	346,507	16.5%
Walpita Estate	150,872	128,118	142,546	188,958	160,124	(- 15.3)
Total	3,055,532	3,905,602	4,769,920	5,418,716	5,591,431	03.2 %

Table 2. *Rain Fall (mm) and Number of Wet Days – (2000 – 2001)*

Month	Bandirippuwa Estate		Isolated Seed Garden		Ratmalagara Estate		PRS	
	2000	2001	2000	2001	2000	2001	2000	2001
Jan	220.6(10)	83.1(05)	102.5 (05)	90.5(09)	89.7(13)	116.2(09)	73.3(04)	82.3(06)
Feb	127.2(10)	40.4(06)	79.5(08)	63.2(07)	231.5(10)	46.1(03)	43.4(04)	61.4(02)
March	164.2(07)	26.2(01)	183.8(08)	-	111.6(08)	-	194.3(06)	-
April	181.5(10)	266.6(14)	255.8(07)	262.6(16)	243.1(09)	231.6(19)	164.9(05)	297.8(13)
May	175.0(11)	43.4(08)	164.6(02)	15.8(07)	157.5(09)	112.8(10)	20.3(01)	08.6(02)
June	126.7(11)	37.4(07)	72.7(03)	46.6(05)	108.2(07)	25.0(08)	65.4(02)	37.0(03)
July	20.7(02)	18.3(08)	01.4(01)	02.9(03)	10.3(02)	05.7(03)	-	02.5(01)
Aug	180.6(11)	05.1(01)	157.6(08)	07.1(04)	177.3(09)	10.3(04)	188.8(07)	-
Sep	207.6(17)	164.8(12)	154.8(09)	134.3(10)	157.1(13)	102.3(12)	147.0(03)	162.0(09)
Oct	107.4(09)	142.0(14)	64.9(07)	137.7(11)	107.7(07)	243.4(13)	163.5(05)	111.6(07)
Nov	76.6(14)	170.9(10)	65.8(16)	171.2(05)	120.0(11)	301.9(13)	51.8(06)	167.2(10)
Dec	103.7(07)	56.8(06)	185.2(08)	32.7(08)	85.71(09)	50.5(06)	160.8(08)	79.8(07)
	1686.6(119)	1055.0(91)	1498.6(87)	964.6(91)	1699.7(107)	1331.1(101)	1273.5(51)	1010.2(60)

Continued Table – 2.

Month	Pallama Seed Garden		Makandura Seed Garden		Maduruoya Seed Garden		Walpita Estate	
	2000	2001	2000	2001	2000	2001	2000	2001
Jan	73.4(04)	94(5)	205.6(09)	92.9(04)	205.3(08)	307.2(20)	247.6(09)	116.7(04)
Feb	43.4(04)	35(2)	165.9(10)	145.5(04)	235 .4(13)	127.2()05)	238.2(12)	91.8(06)
March	109.4(06)	-	116.1(05)	26.0(01)	36.7(05)	01.7(02)	104.2(06)	-
April	154.9(06)	310.5(16)	199.1(08)	437((17)	34.1(03)	242.4(13)	145.0(08)	447.0(01)
May	78.0(01)	17.5(02)	181.7(04)	57.9(05)	19.6(05)	-	206.9(09)	193.0(11)
June	77.2(04)	38(03)	104.4(07)	32.6(05)	22.1(02)	49.0(02)	130.0(07)	84.4(07)
July	-	05(01)	25.2(01)	-	27.9(03)	59.9(04)	52.6(01)	364(05)
Aug	198.7(07)	07(02)	309.7(14)	4.2(01)	79.7(07)	-	332.0(14)	11.2(03)
Sep	145.5(06)	175.(08)	349.3(09)	241.3(09)	57.6(07)	50.9(04)	447.6(12)	219.3(11)
Oct	93.0(05)	154(08)	181.6(11)	256.9(11)	24.0(05)	201.0(11)	141.2(13)	155.6(13)
Nov	61.0(09)	188(09)	76.2(07)	224.6(08)	506.5(12)	280.5(13)	163.1(06)	208.5(09)
Dec	143.0(05)	80(05)	88.4(03)	143.8(02)	257.6(19)	463.1(18)	87.2(03)	94.2(06)
	1176.8(57)	1104(61)	2003.2(88)	1663.0(67)	1506.4(104)	1782.0(91)	2296.1(100)	1718.1(96)

Table 3. *Coconut extent and census of palms*

Estate	Bandirippuwa	Ratmalagara	Ambakelle S.G	Maduruoya S.G	Poththukulama	Walpita	Makandura	Pallama S.G	Dunkannawa	Total
Extent (ha)	123.24	98.34	138.3	71.0	79.28	15.50	53.8	218.8	2.40	800.66
No.of Bearing palms	8154	12740	18055	5508	10321	1838	5055	12388	326	74385
No.of Partial bearing Palms up to 10 years	302	553	1223	1716	168	20	317	092	37	4428
No.of Young palms 2 Years upto bearing	1047	1111	1334	1264	331	10	70	1151	-	6318
No.of Seedlings upto 02 Years	690 + 484	408	42	599	283	-	-	5677 + 2829	-	11012
No.of Weak palms	2920	105	146	484	180	269	2864	1015	-	7983
No.of Vacancies	947	1287	5472	3281	2098	429	1920	7524	1000	23958
Total No.of planting Points	14060	16204	26272	12852	13381	2566	10226	27847	1363	124771

Table 4. *Physical Extent of Estates and Seed Garden (Extent – ha)*

Extent	Bandirippuwa Estate	Ratmalagara Estate	Isolated Seed Garden	Maduruoya Seed Garden	Pothtukulama Estate	Walpita Estate	Makandura Seed Garden	Pallama Seed Garden	Dunkannawa Estate	Total
Mature (ha)	102.24	72.34	109.8	39.0	73.28	15.5	52.8	158.45	2.4	625.81
Immature (ha)	21.0	26.0	28.5	32.0	05.00	-	1.0	60.35	-	174.85
Total (Coconut Estate)	123.24	98.34	138.3	71.00	79.28	15.5	53.8	218.8	2.4	800.66
Nursery	1.61	-	1.00	-	-	-	—	-	-	2.61
Other crops	-	1.00	-	1.0	-	-	-	-	-	2.0
Jungle	-	03.24	304.8	01	-	-	-	29.2	-	338.24
Vacant Land	1.0	05.88	7.1	02.	1.0	-	-	1.0	-	17.98
Reservation/Tank	-	-	3.0	08	-	0.5	2.4	-	7.21	21.11
Roads & Building	22.25	2.02	3.0	2.00	2.5	1.8	2.0	3.0	0.5	39.07
Total	148.1	110.48	457.2	85.01	81.78	17.8	58.2	252.0	10.11	1221.67

Table . 5. *Nut Production in Estates - 2001*

Pick	Bandirippuwa Estate	Ratmalagara Estate	Poththukulama Estate	Walpita Estate	Isolated Seed Garden	Makandura Seed Garden	Maduruoya Seed Garden	Pallama Seed Garden	Total
Pick – 1	120170	129664	117798	23452	247167	98841	52196	118606	807,894
Pick – 2	136327	144652	153629	31882	241235	107911	30745	123160	969,541
Pick – 3	181092	167069	168432	36347	334971	135543	70232	173288	1,266,974
Pick – 4	178081	149912	162493	338850	332629	152741	83061	138750	1,231,517
Pick – 5	87985	97495	129238	21321	229899	102696	63837	85212	817,683
Pick – 6	48797	72054	46316	13272	89960	39147	46436	41930	397,812
Total – 2001	752152	760846	777906	160124	1475761	636889	346507	680946	5,589,441
Av (97 –2001)	603260	559099	723111	153988	1307989	496784	233974	637981	5,591,421
Nut/palm – 2001	78	58	74	81	81	98	60	52	
Nut/palm – 2000	93	60	79	96	85	103	63	49	
Yield/ha - 2001	6665	9510	10472	10330	13440	12108	8864	4186	
Yield/ha – 2000	9745	6658	11389	15055	12719	14080	4438	2894	

Table 6. *Crop Disposal COP and NSA – 2001*

Particulars	Bandirippuwa Estate	Ratmalagara Estate	Pottukulama Estate	Walpita Estate	Isolated Seed Garden	Makandura Seed Garden	Maduruoya Seed Garden	Pallama Seed Garden	Total
Sold	483338	678670	707507	148284	132302	594444	49893	478802	3273240
Coconut Copra	162065	35127	18206	1441	69397	16797	5786	41053	349872
Research	11211	2830	737	1707	11274	-	-	4003	31762
Seed Nut	-	-	9025	-	1007000	-	252718	9600	1278343
Staff Issue	58975	11840	2908	1254	8303	6048	2823	5321	97472
Rejections	31663	27756	39523	4469	17531	21008	12194	37644	191788
Awaiting Disposal	-	-	-	2969	221537	-	15147	104967	344620
Others or Nursery	5200	5073	-	-	8417	-	7946		26636
Total Nos of Nuts	752454	760846	777906	160124	1475761	638297	346507		5593533
COP (RS)	6067/-	4780/-	3039/-	5796/-	3946/-	3140/-	5742/-	6600/-	
NSA (RS)	5812/-	7256/-	6767/-	7196/-	7173/-	7007/-	7697/-		

Table 7. *Total Seed Nut Production In Two Seed Garden*

Seed Garden	2000	2001	Increase/Decrease
Ambakelle Seed Garden	972,824	1,007,000	3.5%
Maduruoya Seed	199,000	252,718	27%
Others Plus Palm	65,087	18,625	71%
Total	1,236,911	1,278,343	3%

Table 8. *Sundry Income*

Estate	Income (Rs)
Bandirippuwa Estate (Treacle,Milk,Food crops Etc.)	458313.00
Ambakelle Seed Garden	413823.00
Poththukulama Estate	35511.00
Rathmalagara Estate	29373.00
Makandura Seed Garden	45467.00
Maduruoya Seed Garden	5758.00
Walpita Estate	152775.00
Pallama Seed Garden	615150.00
Total	1801488.00

REPORT OF THE ADMINISTRATION UNIT
Deputy Director (Administration & Finance) - E P Gunapala
A.P.F.A., B. COM (SP), Diploma in Accountancy

1. GENERAL

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 2001, is given in Table 1:

Table1. *Staff position as at 31/12/2001*

Grade	Ungraded	Sp C1	C1 I	C1 II	C1 III	C1 IV	Total
Executive	01	-	08	12	26	16	63
Technical	-	32	10	26	-	-	68
Intermediates	-	04	01	02	-	-	07
Clerical & Allied	-	24	04	12	-	-	40
Operative	-	18	10	24	-	-	52
Driver	-	18	03	09	-	-	30
Minor	-	46	13	31	-	-	90
Watcher	12	-	-	-	-	-	12
Grand Total	13	142	49	116	26	16	362

3. WELFARE

Welfare facilities extended towards the employees from the Board were continued. Different kinds of financial assistance extended to the employees are given below:

3.1.1 Financial Aid

Provident Fund Loans: Granted for 71 employees, amounting to Rs.12,537,600.00

Distress Loans: Granted for 47 employees amounting to Rs.3,434,300.00

Transport Loans: Granted for 18 employees amounting to Rs.1,045,000.00

Educational Loans: Granted for one employee amounting to Rs.10,000.00

Medical Aid: Rs.2,356,943.00 was reimbursed by the Medical Aid Scheme during the year 2001, and an amount of Rs.498,694.00 was debited to Members Savings Accounts.

3.2 **Other facilities to employees**

(a) Financial assistance was also granted to the Multi-purpose Co-operative Society, the Recreation Club, the Art Circle, the Day Care Center, the Death Donation Society and the Seva Vanitha Movement, during the year 2001.

STAFF MATTERS

1. APPOINTMENTS

Seventeen appointments were made during the year 2001, and the details are given in Table 1:

Table 1. : *Appointments made during the year 2001*

Name	Designation	Division/Unit	Date
Mrs P C A Fernando	Administrative Assistant	Administration Unit	25.01.01
Miss N P I N M Gunathilake	Technical Assistant	Plant Physiology Division	01.03.01
Miss T R Gunathilake	Technical Assistant	Tissue Culture Division	10.01.00
Mr A R A N Kumara	Technical Assistant	Coconut Processing Research Division	01.03.01
Mr W M D R Wijesinghe	Supervisor	Estate Management Division	01.03.01
Mr W M N G Wijethunga	Supervisor	Estate Management Division	01.03.01
Mr W M N G Pradeep	Supervisor	Estate Management Division	01.03.01
Mr N M K S Ranjith	Internal Auditor	Administration Unit	01.03.01
Mr H G Wasantha	Technical Assistant	Agronomy Division	20.03.01
Mr W A S Wickramarachchi	Technical Assistant	Biometry Division	02.04.01
Mr D.W J Jayakody	Forman (Electrical)	Engineering Unit	01.06.01
Mr K D P P Gunathilake	Research Officer	Coconut Processing Research Division	06.06.01
Ms. F F Faruk	Research Officer	Coconut Processing Research Division	06.06.01
Mrs W A N K Wijesinghe	Accounts Clerk	Accounts Unit	06.06.01
Mrs P U D C Dharmapala	Assistant Librarian	Library	03.09.01
Mr W A H Upali	Field Officer	Estate Management Division	03.09.01
Mr C S Herath	Extension Officer	Extension Services Division	02.11.01

2. RESIGNATIONS, RETIREMENTS, VACATION OF POSTS AND TERMINATIONS OF SERVICES

The details are given in Table 2:

Table 2.

Name	Designation	Division/Unit	Date
Resignations:			
Miss H V R Damayanthi	Technical Assistant	Agronomy Division	13.02.01
Mr H P D Soyza	Analyst Programmer	Biometry Division	01.03.01
Mrs C K A Gamage	Senior Technical Officer	Tissue Culture Division	01.04.01
Mrs P A S F Perera	Librarian	Library	01.04.01
Mr R M Gunasekara	Assistant Librarian	Library	02.05.01
Mr A A A Appuhamy	Watcher	Estate Management Division	30.05.01
Mr C L Ranjith	Driver	Administration Unit	01.09.01
Retirements:			
Mr P Daluwatta	Administrative Officer	Administration Unit	07.02.01
Mr K H R L Appuhamy	Senior Office Attendant	Extension Service Division	02.03.01
Mr J A W L Perera	Vehicle Attendant	Administration Unit	15.07.01
Mr D M Jayakody	Senior Field Officer	Crop Protection Division	31.10.01
Mr W T H C Fernado	Senior Lab & Field Assistant	Genetics & Plant Breeding Division	14.11.01
Mr P W A Fernando	Lab & Field Assistant	Agronomy Division	18.11.01
Mr R P Victor	Senior Clerk	Estate Management Division	15.12.01

Vacation of Posts:			
Dr K B Dassanayake	Senior Research Officer	Agronomy Division	04.06.01
Termination of Services:			
Mr D S R Appuhamy	Driver	Administration Unit	31.05.01
Mr M A P Rohitha	Driver	Administration Unit	15.08.01

3. PROMOTIONS

3.1 PROMOTIONS IN NON-EXECUTIVE GRADES

Following Internal Promotions in Non-Executive Grades were implemented during the year 2001, as shown in Table 3. The effective date of these promotions was 01/01/2001.

Table 3. *Promotions in Non-Executive Grades during the year 2001*

Name	Designation	Division/Unit
CLASS 1 - SPECIAL CLASS		
Technical Grade		
Mr D C L Hapuarachchi	Technical Officer	Crop Protection Division
Clerical and Allied Grade		
Mr W P C Fernando	Senior Accounts Clerk	Accounts Unit
Drivers Grade		
Mr C N Luxman	Senior Driver	Establishment Unit
Minor Grade		
Mr B C Mendis	Senior Lab & Field Attendant	Estate Management Division
Mr H A S Perera	Senior Lab & Field Attendant	Crop Protection Division
Mr S M Somarathne	Senior Lab & Field Attendant	Soils & Plant Nutrition Division
Mr G A S Alexander	Senior Office Attendant	Establishment Unit
CLASS II –CLASSI		
Mr P A D M Appuhamy	Lab and Field Assistant	Genetics & Plant Breeding Division
Driver Grade		
Mr K K Piyatissa	Driver	Estate Management Division
Minor Grade		
Mr W Wimalasiri	Lab & Field Attendant	Soils & Plant Nutrition Division
Mrs P J M Fernando	Lab & Field Attendant	Estate Management Division
Mr J H Ubhayaratne	Lab & Field Attendant	Biometry Division
Mr S Abhayatissa	Office Attendant	Estate Management Division

4. TRANSFERS

Mr I M Tilakaratne, Lab & Field Assistant, from Engineering Unit to Agronomy Division, on 01 February.

Mr W A C Fernando, Book Keeper, from Establishment Unit to Accounts Unit, on 01 February.

Mr K P W Perera, Clerk, from Establishment Unit to Bandirippuwa Estate, on 01 February.

Mr T M Keerthiratne, Supervisor, from Ratmalagara Estate to Pottukulama Research Station, on 01 February.

Mr H M Jayathunga, Driver, from Pallama Seed Garden to Establishment Unit, on 01 February.

Mr R M Nihal Sandasiri, Lab & Field Attendant, from Soils & Plant Nutrition Division to Tissue Culture Division, on 01 February.

Mr W A M Wickramasinghe, Watcher, from Ratmalagara Estate to Pallama Seed Garden, on 01 February.

Mr W R O Fernando, Lab & Field Assistant, Ratmalagara Estate to Agronomy Division, on 01 February.

Mr H H J E Appuhamy, Clerk/Typist, from Estate Management Division to Bandirippuwa Estate, on 01 February.

Mr W Sirisena, Lab & Field Attendant, from Makandura Seed Garden to Genetics & Plant Breeding Division, on 01 February.

Mr N M D Chandrasoma, Lab & Field Assistant, from Soils & Plant Nutrition Division to Genetics & Plant Breeding Division, on 01 February.

Mr J H Premaratne, Lab & Field Attendant, from Tissue Culture Division to Soils & Plant Nutrition Division, on 01 February.

Mr J A R Reginold, Clerk/Typist, from Bandirippuwa Estate to Pallama Seed Garden, on 01 February.

Mr H B Perera, Lab & Field Assistant, from Soils & Plant Nutrition Division to Agronomy Division, on 01 February.

Mr W A Sepala Jayatillake, Office Attendant, from Establishment Unit to Coconut Processing Research Division, on 01 February.

Mr W E J Tissera, Lab & Field Assistant, from Ratmalagara Estate to Agronomy Division, on 01 February.

Mr Nimal Stanley, Pollination Labourer, from Isolated Seed Garden to Pallama Seed Garden, on 01 February.

Mr A Sugathadasa, Supervisor, from Poththukulama Research Station to Ratmalagara Estate, on 01 February.

Mr W Wipulasena, Watcher, from Poththukulama Research Station to Ratmalagara Estate, on 01 February.
Mr H M Kirihamy, Senior Driver, from Isolated Seed Garden to Pallama Seed Garden, on 01 February.

Mr H P Karanis, Senior Lab & Field Attendant, from Isolated Seed Garden to Ratmalagara Estate, on 01 February.

Mr H A Abesoma, Technical Officer, from Agronomy Division to Ratmalagara Estate, on 01 February.

Mr H M Manelhamy, Senior Lab & Field Attendant, from Ratmalagara Estate to Isolated Seed Garden, on 01 February.

Mr H M Tikiri Banda, Senior Driver, from Pallama Seed Garden to Isolated Seed Garden, on 02 February.

Mr P R Anil Darmasiri, Technical Assistant, from Coconut Processing Research Division to Extension Services Division on 19 February.

Mr A M Nimal Kularathne, Watcher, from Pottukulama Research Station to Isolated Seed Garden, on 22 February.

Mr H A P B Fernando, Supervisor, from Maduruoya Seed Garden to Isolated Seed Garden, on 20 April.

Mr M P W Fernando, Supervisor, from Makandura Seed Garden to Bandirippuwa Estate, on 20 April.

Mr H D Wasantha, Technical Assistant, from Agronomy Division to Pallama Seed Garden, on 02 May.

Mr D M L Jayaratne, Watcher, from Bandirippuwa Estate to Pottukulama Research Station, on 01 August.

Mr B M Jayathilake, Senior Book Keeper, from Accounts Unit to Estate Management Division on 01 November.

NO-PAY LEAVE GRANTED FOR EMPLOYMENT ABROAD

Table 4.

Name	Designation	Country	Period
Mr N B R Bandara	Guest House Keeper	Singapore	02/04/2001 - 01/04/2003

5. OVERSEAS STUDY LEAVE

Table 5. *Full pay leave in overseas*

Name	Designation	Period	Purpose	Institute
Miss S A C N Perera	Research Officer	15/11/20001 - 16/11/2004	Postgraduate Training to PhD	University of Birmingham, UK
Mr H T R Wijesekara	Research Officer	21/12/2001 - 20/06/2005	Postgraduate Training to PhD	Postgraduate School, New Delhi

6. SABBATICAL LEAVE

Table 6.

Name	Designation	Country	Period
Dr (Mrs) L C P Fernando	Head/Crop Protection Division	New Zealand	02/01/01 - 02/01/02
Dr T S G Peiris	Principal Research Officer	UK	01/10/01 - 01/07/02

7. TRANSPORT UNIT

The administration of drivers and maintenance of the following fleet of vehicles were done by the Transport Unit during the year 2001.

Bus	-	03
Lorry	-	01
Van	-	08
Car	-	01
Elf	-	01
Cab	-	13
Jeep	-	06
Motor bicycle	-	44

8. FINANCE UNIT

The budget expenses during the year were 144.6 million made up of Rs.104 mln. as recurrent and Rs.40.6 mln. as capital expenditure. The total revenue

(excluding transport) for the year was Rs.35 mln. The Government grant was Rs.76.2 mln.

9. ENGINEERING UNIT

The Engineering Unit carried out maintenance work of buildings, electricity, vehicles, and machinery. For the year 2001, the Engineering Unit attended to the following construction and rehabilitation work:

- Construction of a garage at Pallama Seed Garden
- Construction of a fertilizer store at Pallama Seed Garden
- Construction of a labour rest room at Pallama Seed Garden
- Construction of a new toilet at Pallama Seed Garden
- Construction of one agro-well at Pallama Seed Garden
- Construction of one over head tank of Pallama Seed Garden
- Construction of one watcher's quarters at Pallama Seed Garden
- Construction of one agro-well at Bandirippuwa Estate
- Construction of one soakage pit at Bandirippuwa Estate
- Construction of one tractor garage at Bandirippuwa Estate
- Construction of one labour rest room at Maduru Oya Seed Garden
- Construction of a tractor garage at Maduru Oya Seed Garden
- Supply & Installation of a submersible pump at Bandirippuwa Estate

10. LOCAL TRAININGS

Mr U S S Perera, Mr K F G Perera/Senior Technical Officers and Mr H M N B Herath, Mr K P I E Ambagala/Technical Assistants followed a Certificate Course in "Advanced Certificate in Laboratory Technology", from 2000 - 2001.

Mr P R Fernando, Mr S Alahakoon, Mr R A Swarnathilake, Mr K R E M Fernando and Mr M A Hemachandra, followed a Certificate Course in "Managing Coconut Cultivation & Extension", at the National Institute of Plantation Management, in January

Ms Manjula Tennakoon, Research Officer, attended a Seminar on "Towards a Cleaner Industrial Environment in the New Millennium", at the Institute of Chemistry, on 19 January.

Mrs A P Illangakoon, Library Assistant, followed a six-month Course on Library Automation (COLA), at the Sri Lanka Library Association, commencing from February.

Dr (Mrs) C Jayasekara/Acting Director, Mr E P Gunapala/Deputy Director (Administration & Finance), attended a Seminar on "Techniques of Performance Appraisal", at the Institute of Personal Management of Sri Lanka, on 22 February.

Mr N M K S Ranjith, Internal Auditor, attended a Seminar on "Internal Auditing Skill Development", at the Institute of Government Accounts & Finance, from 4 - 6 April.

Mr N A K de Silva, Research Officer, attendant a Seminar on "Spices for the Plantation Sector & Spices Growers", at the Ceylon Chamber of Commerce, from 27 - 29 April.

Dr (Miss) C S Ranasinghe/Head, Plant Physiology Division, Dr K B Dassanayake/Senior Research Officer and Mr A J Wijeratna/Research Officer, attended a Workshop on " Canopy Hemispherical Photography for Measurements of Canopy Parameters", at the University of Peradeniya, on 9 May.
Miss S A C N Perera, Research Officer, attended a Regional Training Programme in Plant Breeding, at the Postgraduate Institute of Agriculture, University of Peradiniya, from 15 - 19 May.

Mr I R Wickramananda and Dr K B Dassanayake/Senior Research Officers and Mr H T R Wijesekara, Mr S Senarathna and Mrs N S Aratchige/Research Officers attended a Workshop on " National Priorities on Plant Protection, Formation of Plant Protection & Formation Association", at the Council for Agricultural Research Policy, on 18.

Mr S S Rajapakse, Technical Assistant, followed a Course on "Data Communication & Computer Networks", held in the Arthur C Clarke Institute for Modern Technologies, from 22 - 28 May.

Dr (Mrs) C Jayasekara, Acting Director, followed a Certificate Course on "Human Resources Management", at the Postgraduate Institute of Management, from 23 May.

Mr A S Nanayakkara, Senior Accounting Assistant, attended a Seminar on "Sri Lanka Auditing Standards", at Institute of Chartered Accountants of Sri Lanka, from 25 May - 15 July.

Miss U G M B K Tennakoon, Research Officer, attended a Seminar on "Water Quality Management - A Need in the New Millennium", at the Institute of Chemistry of Ceylon, on 30 May.

Mr S S Rajapakse, Technical Assistant, followed a Training Programme on "Microprocessor & Micro Controller", at the Atomic Energy Authority, from 31 May - 7 July.

Miss M Jayasundara, Research Officer, followed Training Course on "Hands on Experience for Research Officers in Food Microbiology", at the University of Kelaniya, for three months, commencing from 11 June.

Mr W P R R Fernando/Senior Clerk and Mr K T J N W Perera and Mr M A M Perera, Clerk/Typists, attended a Training Programme, at the Institute of Government Accounts & Finance, from 11 - 13 June.

Mrs S C Fernando/Senior Research Officer and Mrs P T P Perera, Miss D Bandupriya, Mr A J Wijerathna and Mrs W Maddurapperuma/Research Officers, attended a Seminar and a Demonstration on "Access of Information for Chemical

Research Use of IT Facilities", at the Sri Lanka Association for the advancement of Science, on 15 June.

Mr D W J Jayakody, Electrical Forman, followed a Training Course on "Modern Rechargeable Batteries & Management", at the Arthur C Clarke Institute for Modern Technologies, on 20 June.

Mr N A K de Silva, Research Officer, attended a Training Course, at the Postgraduate Institute of Science, on 23 June.

Mr I R Wickramananda/Senior Research Officer and Mr H T R Wijesekara and Mrs N S Aratchige/Research Officers, attended a Seminar and a Workshop on "Insecticide Resistant & Future Trends", at the Sri Lanka Association for the Advancement of Science, from 29 - 30 June.

Mrs P C A Fernando, Administrate Assistant, followed a One-year Course on "Diploma in English", at the Sri Lanka Institute of Development Administration, from 26 July.

Mr E P Gunapala, Deputy Director (Administration & Finance), attended a Seminar on "Low Relating to Termination of Employment", at the Institute of Personal Management of Sri Lanka, on 13 August.

Dr U P de S Waidyanatha, Chairman, Coconut Research Board, participated in a Workshop on "Six Sigma Reengineering & Bench Marking for Organizational Excellence, conducted by the Venture Plus Management Consultant Group, from 29 - 30 August.

Miss S A C N Perera, Miss U G M B K Tennakoon, Miss D Bandupriya and Mrs W Madurapperuma/Research Officers attended a Training Seminar on "Laboratory Quality Management - A Need in the New Millennium", at the Institute of Chemistry of Ceylon, on 31 August.

Miss H D Mangalika, Acting Administrative Officer, attended a Course on "Strategic Management", at the Sri Lanka Institute of Development Administration, from 3 - 7 September.

Mr E P Gunapala, Deputy Director/Administration & Finance, attended a Seminar on "Discipline at Work", at the Retired Sri Lanka Administration Service Officers Association, from 7 - 8 September

Mrs P C A Fernando, Administrative Assistant, attended a Workshop on "Productivity Improvement Teams", at the Sri Lanka Institute of Development Administration, from 10 - 14 September.

Mr S M Sirisoma, Bookkeeper, attended a Training Program on "Accounting Standards Applicable to Public Enterprises", at the Institute of Government Accountants & Finance, from 14 - 15 September.

Mrs M G Karunawathi, Clerk/Typist attended a Computer Training Programme on "MS & Access", at the Institute of Government Accounts & Finance, from 26 - 29 September.

Mr M A D M F Appuhamy, Mr Y H Wijesena, Mr K T J N W Perera, Mr R A L C Fernando, Mr A A D N Athauda, Mr M A M Perera, Mr S Madurawala and Mr W A L R Fernando/Clerk/Typists and Mr W A C Fernando/Bookkeeper and Mr W P C Fernando/Accounts Clerk attended a Computer Training, at the MCI Institute of Computer Technology, for six months, from October.

Mrs S Abeyawickrama, Accounts Clerk, attended a Training Programme for Accounts Clerks, at the Institute of Government Accounts & Finance, from 9 - 12 October.

Mr A J Wijerathna, Research Officer, attended a Short Course on "Design & Analysis of Experiments", at the Postgraduate Institute of Agriculture, Peradeniya, from 22 - 26 October.

Mrs I Somasiri and Mrs M M J R Fernando, Audit Clerks attended a Training Programme on "Internal Auditing Skill Development", at the Institute of Government Accounts & Finance, from 23 - 25 October.

Mr R D Sumanasiri, Bookkeeper, attended a Seminar on "Accounting Techniques", at the Sri Lanka Accounting Association, on 10 November.

Mrs S Saberathnam and Mrs N H R M de Silva/Technical Officers, attended a Seminar on "Laboratory Quality Management", at the Sri Lanka Standards Institution, from 26 - 28 November.

11. OVERSEAS VISITS

Dr U P de S Waidyanatha, Chairman/Coconut Research Board, attended the 10th Meeting of the Coconut Genetic Resources Net work, held in Tanzania, from 11 - 17 June.

Dr (Mrs) L K Weerakoon, Head/Tissue Culture Division, Dr L L W Somasiri Head/Soils & Plant Nutrition Division, Mr P A H Nimal Appuhamy, Head/Extension Services Division and Mr E P Gunapala, Deputy Director/Administration & Finance, participated in Performance Based Management Systems Regional Workshop, held in The Philippines, from 09 - 13 July.

Dr U P de S Waidyanatha, Chairman/Coconut Research Board, attended the Asian & Pacific Coconut Community (APCC) 38th COCOTECH Meeting, held in Vietnam, from 17 - 21 July on invitation.

12. OVERSEAS TRAININGS

Dr L L W Somasiri, Head/Soils & Plant Nutrition Division, attended Short-term Training in Agricultural Research Management, held at Hydrabad, India, from 12 March - 31 March.

Mr R P B H S Senarathne, Research Officer, followed Short-term Training on Fundamental of Modern Weed Control with Herbicides, held at Bangkok, Thailand, from 21 - 25 May.

Dr A A F L K Perera, Senior Research Officer, attended Short-term Training on Molecular Diagnosis of Pathogens, in Australia, from 01 September - 30 December.

Mrs W N I S C Fernando, Senior Research Officer, followed Short-term Training in Cell Cycle Studies in Coconut, held in France, from 01 October - 19 December.

Miss S A C N Perera, Research Officer, commenced her Postgraduate Studies leading to Ph D in the University of Birmingham, UK, from 15 November - 16 November 2004.

Mr H T R Wijesekara, Research Officer, commenced his Postgraduate Studies leading to Ph D in the Postgraduate School, New Delhi, India, from 21 December - 20 June 2005.

STAFF PUBLICATIONS AND COMMUNICATIONS AT SCIENTIFIC MEETINGS

THESES

Ms S C Fernando - Studies on somatic embryogenesis in *Cococ nucifera* L. (coconut). Ph D thesis, University of Colombo.

JOURNALS, PRESENTATIONS AT SEMINAR/WORKSHOPS AND SCIENTIFIC SESSIONS

Fernando, K S K S, Tennakoon, N A and Vidanapathirana, S 2001. Identification of soil micro organisms (bacteria fungi) in different coconut growing soils in Sri Lanka. Cocos. J of Coconut Research Institute, Lunuwila (IN PRESS).

Fernando, M T N and Samarajeewa, A D (2001). Establishing a framework and selecting project sites for a nationwide deployment of coconut-based poverty reduction interventions in coconut-growing communities using COGENT's 3-proaged strategy in Sri Lanka . Report of the IPGRI/DFID-funded Socio-economic. Survey (LOA: AP01/020). Coconut Research Institute of Sri Lanka 58pp.

Gunathilake, H A J (2001). Cashew - A suitable mixed crop for marginal coconut lands. *Journal of the National Institute of Plantation Management.* 17 (1), p87.

Gunathilake, H A J (2001). Intercropping and farming systems in coconut lands. Govikam Sangarawa, 51(2).

Hettiarachchi, H A D T, Fernando, M T N and Ratnasiri, S C (2001). Opportunities for commercial cultivation of medicinal plants under coconut. In: Proceedings of 1st Agricultural Research Symposium. 25-26 June 2001, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka (ed.) S J B A, Jayasekara, T S G Fonseka and W J S K Weerakkody, 261-267.

Jayasinghe, J A S S C, (2001) studies on cryopreservation of mature zygotic embryos of coconut (*Cocos nucifera* L.). A research project report submitted to the Open University of Sri Lanka for the requirement of BTU 3200 (Research Project in Botany ; the project was supervised by Dr L K Weerakoon).

Mewan, K M, Liyanage, A C, Everard, J M D T, Gunasekera, M T K, Fernando, W M U, Karunanayake, E H. (2001) Estimation of genetic relatedness of Tea (Carica pupaya L.) germplasm using RAPD technique. Sri Lanka Assoc. Advmt. Sci 57 (1) : 191.

Nainanayake, N P A D, Bandara, D C, Ranasinghe, C S (2000-2001) The impact of soil type. Soil compaction and water stress on above and below ground components of coconut (Cocos nucifera L.) seedlings. Cocos 14 (in press).

Perera, L, Russell, J R, Provan, J & W Powell (2001). Levels and distribution of genetic diversity of coconut (Cocos nucifera L. var. Typica form Typica) from Sri Lanka assessed by microsatellite markers. Euphytica 122, 381-389.

Perera, L (2001) Origin, Domestication, Dissemination and Genetic Diversity of Coconut: DNA Information CORD 17, 35-51.

Peiris, T S G, (2001) Experimentation in tree crops – An Alternative analysis. Newsletter of the Applied Statistical Association of Sri Lanka (Vol. 3).

Ranasinghe, C S, Mathes, D T, Silva L R S, Kularatne, J D J S (2000-2001) . A non-destructive method for determining leaf area of unsplit leaves of coconut seedlings. Cocos 14 (in press).

Ranasinghe, C S, Wimalasekara, R, Nainanayake, N P A D (2001) Simulated sea shipment of tender king coconut : effect of storage conditions on the keeping qulaity. PLACROSYM XIV, Hyderabad, India (in press).

Samarajeewa, S R, Thanaweera Arachchi, P T, Fernando, M T N and Ratnasiri, H G S C (2001) Supply response analysis in coconut production. In Proceedlings of the 57the Annual Session of the Sri Lanka Association for the Advancement of Science (SLAAS), Part 1, 26 November - 01 December 2001, Colombo.

Somasiri, L L W, Wijebandra D M D I, Panditharatne, D P, Sabaratnam, S, Kurundukumbura, C P A and Pathirana, K P. Study on nutrient removal by Typica x typica coconut palms in high potential lands. Proceedings of the 57th Annual Session of the SLAAS.

Thanaweera Arachchi, P, T, Samarajeewa,, S and Rathnasiri, N G S C (2001) Supply Response of Coconut Production in Sri Lanka. Proceedings of the Agric. research Symposium, Faculty of Agriculture, Wayamba University of Sri Lanka, Makandura, Gonawila 25-26 June.

Weerakoon, L K. Organization Performance Assessment of the Coconut Research Institute (CRI) of Sri Lanka. Paper presented at the First Regional Workshop of the PHMS Project in Manila 9-12 July.

Wijesekara H T R, "Leaf Rot Disease of Coconut" paper article Ceylon Daily News.

Wijesekara, H T R "New Decline Syndrome of Coconut" COCONEWS 3.1

Wijebandara, D M D I and Somasiri, L L W. (2001) Critical value of available soil phosphorus for Pueraria phasealotdes cultivation to low country of Sri Lanka. Proceedings of the 21st Annual Session of the Institute of Biology, Sri Lanka.

Wijebandara, D M D I and Somasiri, L L W. (2001) Coconut husk as a source of potassium for your palms Coco News 1 (3): 1.

Wijebandara, D M D I (2001) Macro and micro nutrient removal by a coconut palm. Paper presented at the In-house seminar held in Coconut Research Institute, 06 June 2001.

REPORT OF THE ACCOUNTS UNIT
FINANCIAL PERFORMANCE REPORT
R M U Chandranath BSc Mgt.

The Coconut Research Institute receives funds from the consolidated fund for its maintenance. Its secondary income sources are three Coconut Seed gardens, five coconut estates, analytical and advisory services and funds received from the projects. Table 1 shows funding received from the Treasury, total income generated through Seed gardens and estates, and Cess money received for the last four years.

Table 1. Grants from Treasury, CESS, other sources and income form Seed Gardens and Estates

Sources	Rs. Million			
	1998	1999	2000	2001
Treasury	81.43	61.15	91.61	76.20
Income from Estates	30.55	38.77	27.71	41.95
CESS	2.57	38.36	45.17	17.88
Other Sources (Projects)	1.27	4.34	2.15	4.70
Total	115.82	142.62	166.64	140.72

As given in Table 1, funds received from the Treasury decreased by 20% in the year 2001 compared to year 2000. The income generated by estate operations in 2001 was Rs. 41.9 million which was an increase of 34% over Rs. 14.2 million in 2000.

Of the total approximately 54% and 30% of recurrent and capital expenditure were obtained from the Treasury grant and income generated by Estate operations, funds received from Coconut Cess and local / foreign grants were 16%, 13% and 3% respectively (Table 3-4).

Sales and Profit Trends of Estates

The trend of sales and profit of all the estates during 1998 –2001 are given in table 2 .

Table 2. Sales and Profits of the Estates

Estates	1998		1999		2000		2001	
	Sales Rs. mln.	Profit (Loss) Rs. mln	Sales Rs. mln.	Profit (Loss) Rs. mln.	Sales Rs. mln.	Profit (Loss) Rs. mln.	Sales Rs. mln.	Profit (Loss) Rs.mln.
Bandirippuwa Estate	3.38	-0.15	4.09	0.33	2.63	-2.24	5.17	0.30
Rathmalagara Estate	3.79	1.25	3.85	0.88	3.07	-0.73	6.12	1.50
Ambakele Seed Garden	12.49	7.60	14.26	8.74	7.73	1.36	13.66	6.74
Pottukulama Estate	5.09	2.75	6.56	3.96	4.62	2.09	3.50	0.65
Walpita Estate	1.21	0.33	1.11	0.03	1.07	-0.06	1.35	0.11
Makandura Estate	2.87	1.57	2.37	0.67	3.53	1.36	3.93	1.50
Maduru oya Seed Garden	1.73	0.41	2.20	0.35	1.57	-0.57	2.34	-0.25
Pallama Seed Garden			4.33	1.53	3.50	-1.01	5.89	1.24
Total	30.56	13.77	38.77	16.49	27.71	0.20	41.95	11.78

During the year 2001, 1,278,343 seed nuts were produced from Ambakelle and Maduru Oya seed gardens and from plus palm at Pottukulama, Pallama and Rathmalagara Estates. The total yield of coconut in all eight estates was 5,591,431 nuts which was an increase of 3% over the previous year. Total income of the estates are given in Table 2. The estates sundry income and income from livestock sector amounted to Rs.2.020 million.

Figure a:

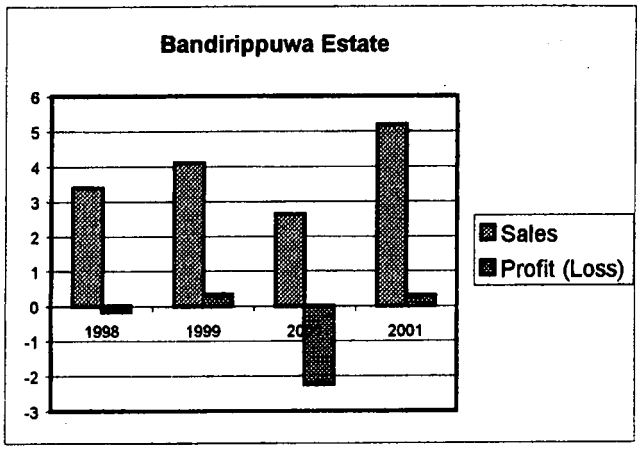


Figure b:

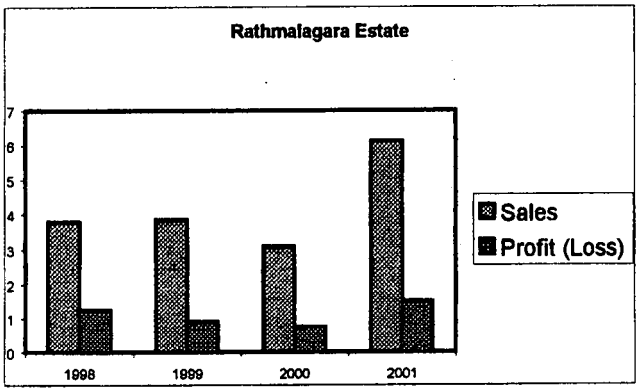


Figure c:

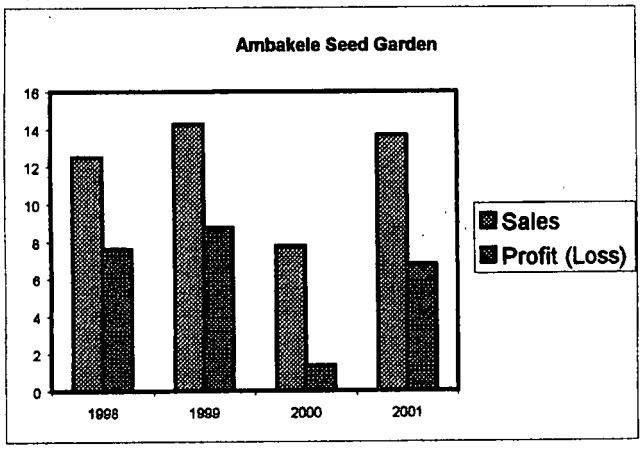


Figure d:

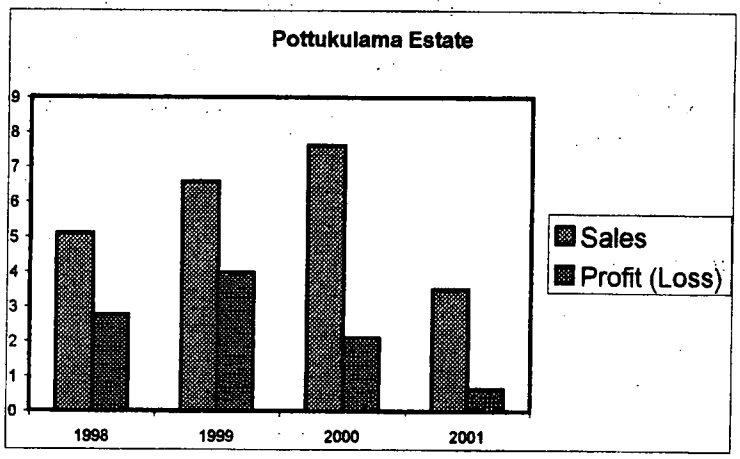


Figure e:

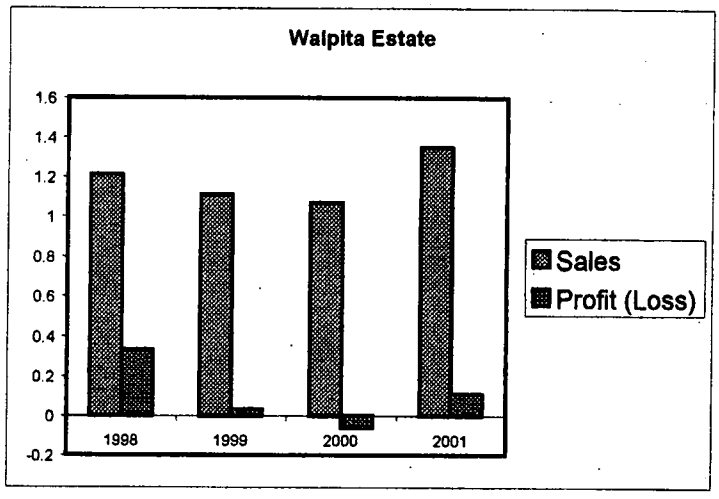


Figure f:

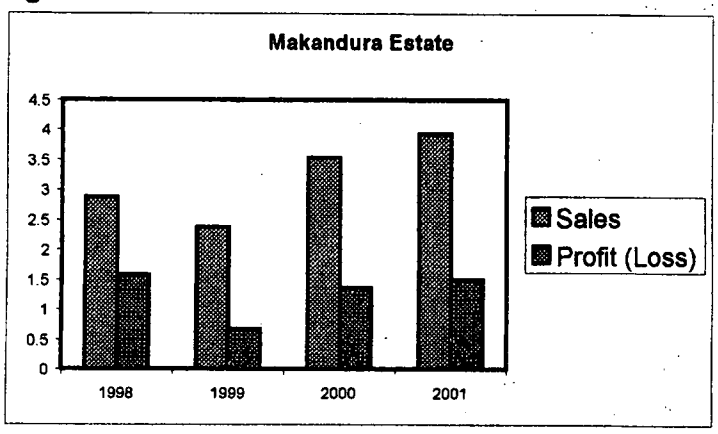


Figure g:

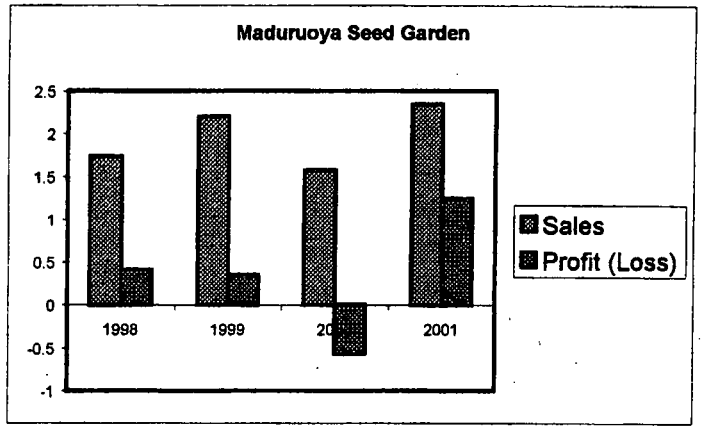


Figure h:

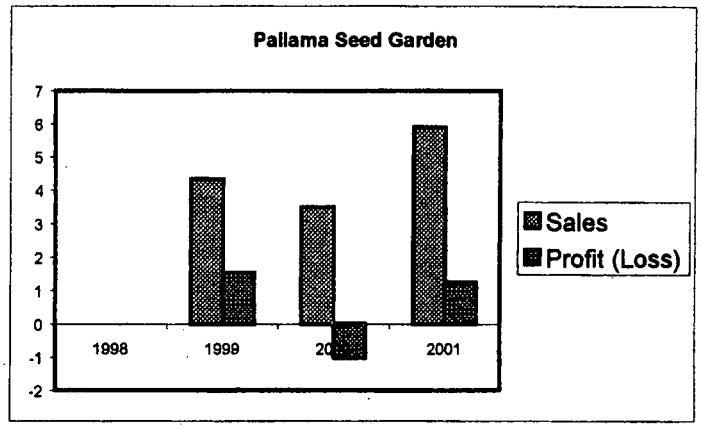
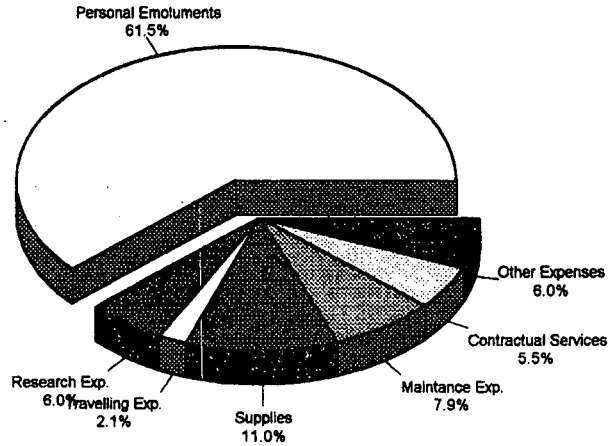


Figure a-h shows the trends on sales and profit of estates of the Coconut Research Institute for 1998 – 2001. The reason for the decline an income of Bandirippuwa Estate , Rathmalagara Estate , Walpita Estate , Maduruoya Estate , and Pallama Seed Garden was low coconut prices prevailed in 2000.

Recurrent Expenditure of the Institute



Utilization of consolidated funds and the income from estate operations for CRI activities are given in Figure 2.

Table 3. BALANCE SHEET AS AT 31 ST DECEMBER 2001

		COST VALUATION Rs.	ACCUMULATED DEPRECIATION Rs.	W.D. VALUE ON 31.12.2001 Rs.	VALUE ON 31.12.2000 Rs.
FIXED ASSETS	**NOTE-01**	222,955,255.19	**77,355,659.26**	**145,599,595.93**	**136,552,999.47**
CURRENT ASSETS					
STOCKS	**NOTE-02**	17,134,929.88			10,344,709.33
DEBTORS LESS PROVISION	**NOTE-03**	3,756,126.38			3,802,575.26
PURCHASE ADVANCES	**NOTE-04**	4,219,517.74			2,138,094.55
LOANS AND ADVANCES TO EMPLOYEES	**NOTE-05**	16,337,701.45			16,031,284.22
DEPOSITS RECEIVABLE		134,400.00			134,400.00
SAVING DIPOSIT	**NOTE-06**	539,122.01			491,950.58
PREPAYMENTS		2,725,442.84			1,449,329.78
I.A.E.A. PROJECT		5,513.29			5,513.29
CASH -IN -TRANSIT		3,600,000.00			2,340,313.10
CASH & BANK BALANCES	**NOTE-07**	10,325,255.92			15,723,610.53
			58,778,009.51		**52,461,780.64**
LESS- CURRENT LIABILITIES & PROVISIONS					
SUNDRY CREDITORS	**NOTE-08**	377,523.74			320,868.59
ACCRUED EXPENSES		12,035,077.47			4,476,665.74
EXPENCE CREDITORS		1,916,320.64			1,916,320.64
DEPOSITS PAYABLE	**NOTE-09**	476,849.93			507,297.05
ON GOING PROJECTS	**NOTE-10**	5,872,653.69			7,283,593.45
			20,678,425.47		**14,504,745.47**
				38,099,584.04	**37,957,035.17**
				183,699,179.97	**174,510,034.64**

WORKING CAPITAL

CAPITAL				
AUTHORISED CAPITAL			18,000,000.00	18,000,000.00
SURPLUS OF THE GRANT AFTER RECURRENT EXPENDITURE	**NOTE-11**		**220,010,959.10**	**198,645,016.87**
FOREIGN AID			**634,078.78**	**634,078.78**
LOCAL AID			**4,819,171.82**	**4,819,171.82**
RESERVES				
CAPITAL RESERVE	**NOTE-12**	11,218,173.46		10,230,561.72
REVENUE RESERVE	**NOTE-13**	52,983,203.19		39,818,794.55
			41,765,029.73	**29,588,232.83**
			183,699,179.97	**174,510,034.64**

Table 4. INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 ST DECEMBER 2001

PROGRAME	NAME OF ACCOUNT	EXPENDITURE Rs.	INCOME Rs.	SURPLUS/(DEFICIT) 2001 Rs.	SURPLUS/DIFICIT 2000 Rs.
01	ADMINISTRATION DIVITION	79,932,910.90	1,563,438.27	(78,369,472.63)	(66,103,618.68)
02	TISSUE CUL TURE DIVITION	968,877.97		(968,877.97)	(495,590.80)
03	GENETICS & PLANT BREEDING DIVISION	1,286,818.26	664.60	(1,286,153.66)	(1,053,221.16)
04	SOILS & PLANT NUTRIION DIVISION	1,495,083.27	64,839.75	(1,430,243.52)	(1,718,700.37)
05	AGRONOMY DIVISION	2,092,256.22	485,761.46	(1,606,494.76)	(1,722,313.98)
06	CROP PROTECTION DIVISION*	676,889.96	146,563.19	(530,326.77)	(752,450.15)
07	BIOMETRY DIVISION	379,772.29		(379,772.29)	(499,297.26)
08	PLANT PHYSIOLOGY DIVISION	1,026,927.90		(1,026,927.90)	(744,414.93)
09	COCONUT PROCESSINGRESEARCH DIVISION	685,789.38		(685,789.38)	(452,389.22)
10	EXTENSION SERVICES DIVISION	835,860.28	25,325.85	(810,534.43)	(597,187.92)
11	LIBRARY SERVICES DIVISION	1,411,671.74	111,835.50	(1,299,836.24)	(1,876,602.85)
12	ESTATE MANAGEMENT DIVISION	54,788.42		(54,788.42)	(117,327.89)
13	WORKING ACCOUNT - ESTATE	15,077,348.54	34,263,558.72	19,186,210.18	200,414.62
		105,924,995.13	**36,661,987.34**	**(69,263,007.79)**	**(75,982,700.59)**