



INTERNATIONAL CONFERENCE

75TH ANNIVERSARY
COCONUT RESEARCH INSTITUTE
OF SRI LANKA

ABSTRACTS



September 8-11, 2004
Hotel Trans Asia, Colombo, Sri Lanka

INTERNATIONAL CONFERENCE

COCONUT RESEARCH INSTITUTE OF SRI LANKA

“Tree of Life – New Trends in the Millennium”

PROCEEDINGS - Part II

ABSTRACTS

Editors

T S G Peiris

C S Ranasinghe

September 8 -10, 2004

Trans Asia Hotel, Colombo 01, Sri Lanka

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The Coconut Research Institute of Sri Lanka (CRISL)

Bandirippuwa Estate, Lunuwila 61150, Sri Lanka

Website: www.cri.lk

Published in 2004

ISBN: 955-9013-04-1

Printed by

Technology Transfer Division

CRISL

The corrected citation of these proceedings is:

Author (s). Title of the paper. In: *Proceedings of the International Conference of the Coconut Research Institute of Sri Lanka – Part 11 (Abstracts)*. page numbers. (Eds: T. S. G. Peiris and C. S. Ranasinghe). The Coconut Research Institute of Sri Lanka, Lunuwila 61150, Sri Lanka.

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New Technologies of Coconut Processing

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Technical Session I

Guest Presentations

Session Chairman -

Mr. J Abeywickrema

Secretary

Ministry of the Plantation Industries

**CAN THE COCONUT MITE (*ACERIA GUERRERONIS* K.) BE
MANAGED IN FUTURE?**

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The coconut mite can be managed. For this two strategies are required. The short term strategy is directed at the existing trees and the long-term strategy at the future plantings. On the existing trees the mites can be managed by providing the recommended dosages of fertilizers (NPK @500g, 300g, 1200g/palm/year) and manures, inclusion of a plant protection schedule (root feeding azadiractin (5%) containing pesticides at 7.5 ml per palm) further enables reduction of loss by the mite. This is based on field studies, hence governments in Southern India have taken large scale demonstration programmes to educate farmers about the need to provide nutrients to palms to manage this mite. The long term approaches are directed at future planting programmes. The seed nuts should be selected from trees showing <15% nut surface damage. Marker based techniques for identifying the seedlings before planting need to be developed. Developing strains of the fungal bioagents is another strategy that would help in enhancing natural suppression of the mite.

INTRACELLULAR PATHOGENS OF COCONUT PALM

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Intracellular plant pathogens include viroids, viruses, and phytoplasmas. They replicate within cells and spread through the agency of vectors or propagules. In coconut palm, two viroids and one virus have been described. Phytoplasmas are associated with a number of coconut palm diseases, but are not fully characterised. A number of unexplained disorders of coconut palm occur in various countries and research is required to determine whether these may be caused by intracellular pathogens. Control or management of a disorder depends on identifying the cause and both the identification of new intracellular pathogens and diagnosis of previously described members of this group currently rely on nucleic acid technology. Examples will be given of the application of this technology to solving the etiology of cadang-cadang, tinangaja and foliar decay diseases of coconut palm, and its application to researching other diseases of unknown cause.

Technical Session II

**Review Papers on Different Disciplines of
Coconut Research**

Session Chairman -

Dr. P Rethinam

Executive Director

Asian and Pacific Coconut Community

**FROM CEYLON LATIN SQUARE TO COCONUT GENOME
FRAMEWORK: A RELENTLESS JOURNEY**

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Coconut breeding has progressed a long way initiating from studies on basic taxonomy and advancing up to genomics in the Coconut Research Institute of Sri Lanka (CRISL). During the 75-year passage CRISL has reached the grower with three promising varieties, CRIC60, CRIC65 and CRISL98 and soon with two more, dwarf green x San Ramon (Kapruwana) and dwarf brown x tall. Studies on mass selection, progeny evaluation, inter and intra-varietal hybridization, production of improved cultivars and multi-locational evaluation of such generated ample information for the breeder as well as scientists of other disciplines. The facilities developed at CRISL for mass production of seed coconuts fulfill a major requirement of the industry by supporting the national coconut replanting programme (NRP). Consorted efforts of CRI and COGENT that resulted in conservation of almost the entire coconut germplasm in the country is indeed a remarkable achievement. Phenotypic and molecular marker based characterization of germplasm unveiled true genetical structure of the coconut palm population elucidating the narrowness of the genetic base in the country thus limiting plant breeders to exploit already exploited variation within the limits of conventional breeding. The limitation in genetic variation was addressed by enrichment of germplasm via safe importation of 14 new coconut varieties from India

and Papua New Guinea. Utilization of enriched germplasm by conventional means, hybrid production to offer a wider choice of planting material for grower and applying novel tools of molecular biology combined with comparative genomics for more precise utilization of genetic variation are seen by CRISL as strategies for meeting the changing needs of coconut industry in the new millenium.

**COCONUT TISSUE AND EMBRYO CULTURE RESEARCH IN SRI
LANKA: CURRENT DEVELOPMENTS AND FUTURE
CHALLENGES**

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Conventional propagation of coconut by the use of seednuts induces a high degree of variation in yield and other characters. The advantages to be gained by eliminating this variability are immense, and therefore, vegetative propagation of coconut by means of tissue culture is highly desirable. However, coconut has remained highly recalcitrant to propagation through tissue culture. Even though plant regeneration from various tissue explants is possible through a process of somatic embryogenesis, the success rate is very low due to numerous constraints. Thus a greater understanding of embryogenesis backed by basic research is necessary to overcome these constraints, and make a break through in developing an efficient cloning technique for coconut. Research efforts have also been concentrated on mature zygotic embryo culture of coconut as a tool for collection, exchange and conservation of coconut germplasm. This technology can also be applied to rescue embryos of non-germinating and economically important types of coconut.

FERTILIZER RECOMMENDATIONS IN SRI LANKA TO INCREASE COCONUT PRODUCTIVITY

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The first properly designed first fertilizer experiment (3x3x3) in coconut was established in 1935. Since then various long-term field experiments (> 5 yrs) have been conducted for young and mature palms by the CRI at different soil classes within agro-ecological regions. The source, application rates, application methods, and time and frequency of fertilizer applications were changed from time to time, but the major nutrients recommended were N, P, K. and Mg. Having established a relationship between leaf nutrients and nut yield, location specific fertilizer application was introduced in 1990. New research areas on fertilizers, to increase the productivity of coconut lands are highlighted.

**MONOCULTURE TO CROP DIVERSIFICATION: A PARADIGM
SHIFT TOWARDS COCONUT PRODUCTION**

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Coconut is the largest plantation crop in Sri Lanka and the second largest after rice. Out of 0.45 million hectares of coconut 58 per cent belongs to smallholder with an average of 0.5 hectare per farmer. It is estimated that 700,000 coconut farmer households depend on their income on coconut. Available lands for new planting of coconut are limited and monoculture coconut gives only a low income to the farmer. On the other hand monoculture coconut is not in favor for efficient utilization of resources such as soil, water and sunlight. Hence, monoculture to crop diversification is a must for income generation for all levels of coconut growers. Intercropping, multiple cropping, mixed cropping, alley cropping and mixed farming are the main systems in coconut based farming systems (CBFS) in Sri Lanka. Any one of these intensive well-designed farming systems with adequate agronomic requirements would not affect on coconut yield. Actual benefits; increase in soil fertility, improvement of coconut palm nutrients, creation of favorable micro-climate and increase sustainability of coconut lands are discussed in detail. Research findings of the Coconut Research Institute on the suitability and profitability of various crops, animals and fuel wood farming and their integration in coconut farms are discussed.

**FORECASTING COCONUT PRODUCTION: ISSUES,
APPROACHES, CHALLENGES**

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This paper reviews the studies that have been carried out by the CRISL on prediction of annual and seasonal coconut production, including various issues related to development of yield prediction models at farm, regional and national level and discusses the future research needs. Irrespective of spatial scale, the common approach for yield prediction has been the use of first or second order general linear models in which rainfall was the key predictor variable. Non-linear models have shown poor predictability on national production. Stochastic models have been more successful in predicting national yield production than crop x weather models in respect of accuracy and the lead-time. As an alternative method, crop x climate x technology model was developed in 2004 for predicting the national coconut production. The key predictor variable in this model was quarterly rainfall in agro-ecological regions in coconut growing areas. As quarterly rainfall is significantly related to regional and national coconut production, prediction of quarterly rainfall would be a major challenging problem in yield prediction studies.

ACHIEVEMENTS IN PEST AND DISEASE MANAGEMENT OF COCONUT IN SRI LANKA

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Out of many pests and diseases that attack the coconut palm in Sri Lanka, a few are considered economically important. The achievements in the development of successful management strategies for leaf miner (*Promecotheca cumingi*), coconut caterpillar (*Opisina arenosella*), red weevil (*Rhynchophorus ferrugineus*) and bole and root rot disease are reviewed. Excellent efforts of the scientists of the Coconut Research Institute and inter-institutional cooperation have resulted in these successful outcomes. Control of leaf miner by introduced parasitoids has been recorded as a text book example of successful classical biological control. The coconut caterpillar could be effectively managed by augmentation of laboratory-bred parasitoids. An effective integrated management package has been developed for red weevil although it is still a serious pest. The reasons are discussed. Research in developing an integrated management method for the recently introduced coconut mite is discussed. The need to re-address management strategies for other important pests and a strategic approach to prevent and control future threats of new introductions are highlighted.

**PHYSIOLOGY OF COCONUT AS A RATIONAL BASIS FOR CROP
IMPROVEMENT: ACHIEVEMENTS AND CURRENT DEVELOPMENTS
IN SRI LANKA**

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This review highlights the significant findings of research on coconut physiology at the Coconut Research Institute of Sri Lanka (CRISL) since its inception. The work was focused mainly on physiological and biochemical features of the coconut palm to understand their reference to eco-physiological problems, in order to achieve sustainable high productivity. Studies on leaf area development, photosynthetic characters of the canopy, light use efficiency, dry matter production, assimilate partitioning pattern, water use efficiency and critical stress levels during the formation of different fruit components have generated basic information of the crop that can be used by breeders, agronomists and physiologists. With respect to the drought management in coconut, physiological tools that could be used to screen coconut palms for drought tolerance were evaluated and variation in leaf stomatal conductance with soil moisture deficit was found to be the best tool. Screening of mother palms for physiological stability using these tools was introduced in the breeding programme. Of the available cultivars, CRISL98 and CRIC65 were found to be best performers under moisture deficit and moisture unlimiting conditions, respectively. The effectiveness of different mulches, utilized to conserve soil moisture, in improving the palm water status during dry periods was also determined. Changes in

physiological parameters of coconut palms affected by disorders of unknown etiology were quantified. This would enable early diagnosis and evaluation of different treatments on the recovery of these disorders. For the benefit of toddy tapping industry, CRIC65 was identified as a high toddy yielding variety, sequential production of toddy and nuts in the same palm was identified as a more profitable production systems than producing nuts and, 2.5% Ethrel was identified as a chemical stimulant to improve toddy yield. A technology to improve shelf-life of tender king coconut for a period of one month was developed for the benefit of tender nut beverage industry. Based on this work, several future research directions for meeting challenges of coconut industry are proposed.

**A SELECTION OF PROSPECTS FOR IMPROVEMENT,
DIVERSIFICATION AND VALUE ADDITION FOR TRADITIONAL
AND NOVEL COCONUT PRODUCTS**

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Coconut is a versatile tree, which can be used to produce value added products from many parts of the tree. Several decades ago processing sector was mostly confined to a few traditional products such as copra, coconut oil, desiccated coconut and coir. Today processing sector has gradually progressed into a vast array of new products from its products and by-products. To maintain economic stability, enhance exports, and additional income for the coconut sector product diversification and value addition are very important. Strengthening of informal sector to produce more value added products at community level or by villagers using simple technology would be an answer to increase income of smallholder sector. Emerging new prospects for product diversification and some strategies to address issues related to processing sector are discussed.

Technical Session III

**Breeding, Conservation, Modern
Biotechnology and Tissue Culture**

Session Chairman –

**Dr. P. Batugal
Co-ordinator,
COGENT, IPGRI**

USE OF MICROSATELLITE DNA MARKERS FOR POPULATION ANALYSIS, VARIETY IDENTIFICATION AND FOR HYBRIDITY TESTING OF COCONUTS IN SRI LANKA

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Eighteen microsatellite (SSR) primers were used to estimate the genetic diversity of coconuts in Sri Lanka. Overall high level of genetic diversity was revealed for Sri Lankan coconuts with tall coconuts showing a higher level of diversity compared to that of dwarf coconuts. Genetic relationships among Sri Lankan coconut varieties were also established with the same set of primer pairs and a great improvement in detecting genetic relationships was observed compared to the previously established genetic relationships using only eight primer pairs. Three SSR primers were identified, which can be used to accurately distinguish coconut varieties used as parents in the breeding programme of Sri Lanka and to confirm the hybridity as well as uniquely distinguish between two commercially growing coconut hybrids in Sri Lanka. Sequence information and other relevant information of twenty new SSR primer pairs are also presented.

THE SUCCESSFUL MASS PRODUCTION OF THE MAKAPUNO COCONUT BY EMBRYO CULTURE IN THE PHILIPPINES

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There is an economically important soft endosperm coconut in the Philippines, which is called Makapuno. This coconut is borne by the Laguna Tall variety and gives only 0 to 25% Makapuno. This is characterized by a soft gelatinous endosperm that almost fills the cavity of the nut. A single recessive gene governs the Makapuno phenomenon and the coconut bearing Makapuno is heterozygous for the character. Makapuno coconuts do not germinate in situ because the abnormal condition of the liquid and solid endosperms cannot support the growth and development of the embryo. The embryo culture technology was first developed in the 1960s to rescue the embryo from the non-germinating Makapuno by Dr. Emerita de Guzman. These palms would give up to 100% Makapuno nuts depending on how these are planted. The technique has since then been optimized at the PCA-Albay Research Center and is now being used to mass propagate the Makapuno coconut in the Philippines as well as in collecting, conserving and transporting coconut germplasm among and between coconut growing countries in the world. There are now 9 Makapuno embryo culture laboratories in strategic locations in the Philippines. These laboratories are adequately equipped and are capable of producing embryo cultured Makapuno coconuts for sale to interested individuals in the region. Demonstration farms to showcase Makapuno farming have also been established in the area. Other support activities to develop and promote the advantage of growing Makapuno coconuts are also conducted and will be presented.

**GENOME MAPPING USING SRI LANKAN COCONUT
GERMPLASM: CURRENT STATUS AND FUTURE**

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Linkage maps are useful tools for breeders who wish to employ trait-marker associations in breeding programmes. A high priority has been given to develop a fine linkage map for coconut (*Cocos nucifera* L.), though it is a difficult task for almost all perennial crops. Several attempts have already been made to map the coconut genome and to tag quantitative traits by various scientists in the world with a significant achievement but have encountered various difficulties. A segregating population of coconut derived by selfing dwarf green x tall hybrids in Sri Lanka was used to construct a linkage map with little success because the mapping population appeared to be adulterated and the attempts taken to sort it out were not effective. This paper illustrates the importance of developing a linkage map of coconut, indicating restrictions in application, past experience and future work.

GENETIC FIDELITY AND *EX VITRO* PERFORMANCE OF TISSUE-CULTURED COCONUT PLANTS

S. C. Fernando, L. K. Weerakoon, P. I. P. Perera, H. D. D. Bandupriya, I. E. Ambagala, C. K. A. Gamage, E. S. Santha, T. R. Gunathilake and L. Perera

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A limited number of clonal plants of coconut has been regenerated from various explants through somatic embryogenesis, and successfully field planted. Evaluation of the performance of such plants is essential, as the regeneration via an *in vitro* phase may possibly induce variations among regenerants. Therefore genetic variation of tissue-cultured coconut plants of the varieties, Sri Lanka Tall and Dwarf green X Tall, were studied using microsatellite DNA markers and ploidy level of these plants were analyzed by flow cytometry. The growth parameters (plant height, girth at collar and number of leaves) of the plants were recorded to evaluate their *ex vitro* performance. Ploidy analysis demonstrated that tissue-cultured coconut plants are diploids while microsatellite DNA markers confirmed the absence of variants among plants within clones. Analysis of growth parameters revealed that due to the smaller size of clonal plants at the time of *ex vitro* transfer, they require a prolonged acclimatization period compared to embryo-cultured plants. However, their growth performance after acclimatization was comparable to that of seed nut-derived coconut plants and they bear normal nuts. This paper, for the first time, reveals that despite the difficulties encountered in coconut tissue culture, the *in vitro* plant regeneration protocol developed is capable of regenerating genetically stable coconut plants, that grow normally after acclimatization and field transfer.

**PERFORMANCE OF CPCRI PROTOCOL OF COCONUT EMBRYO
CULTURE IN GERMPLASM EXPEDITION**

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The CPCRI protocol of coconut zygotic embryo culture was utilized for five germplasm expeditions during the period 1997-2001. A total of 4182 embryos of 45 accessions were collected from 8 countries viz., Mauritius, Madagascar, Seychelles, Maldives, Comoros, Reunion, Sri Lanka and Bangladesh. The per cent retrieval of embryos varied among the location and among accessions. A major cause of differential germination was the contamination of cultures, which could be partially attributed to the personal skill and the conditions of the site at the time of collection. Treatment of cultures with tetracycline (2 ppm) be effective in treatments of cultures with mild bacterial contamination. The per cent germination varied between 54 (Sri Lanka) to 82.2 % (Bangladesh) between expeditions. In earlier expeditions when seed nuts were brought, the germination ranged from 2.0 – 87.0%. The observation on *in vitro* retrieval of embryos and their *ex vitro* establishment suggest that, about 300 to 400 embryos/accessions needed to be collected for field establishment of 100 plants in a gene bank.

SCREENING OF COCONUT GERMPLOSM FOR DROUGHT TOLERANCE BASED ON PHYSIOLOGICAL TRAITS

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Impacts of frequent droughts on coconut in the main coconut growing areas of Sri Lanka which cause substantial reductions in coconut yield were investigated. The main objective was to identify coconut forms or accessions (form/acc) with drought tolerance from the available coconut germplasm pool in the Coconut Research Institute of Sri Lanka (CRISL) using physiological parameters. The emphasis was on form/acc that might show substantial yields under drought conditions rather than mere survival. Physiology based rapid evaluation criteria instead of time consuming, yield based methods were tested. This paper mainly concentrates on the application of cluster analysis as an analytical tool for overall evaluation using nine parameters extracted from basic physiological data. Five form/acc (SRR, SRG, CL, DT and DYT) were identified as better performing form/acc under water deficits. Maintenance of high internal water status even under depleting soil moisture conditions was important by enabling maintenance of high rate of photosynthesis. Thus evaluation of coconut palms using both internal water status (RWC or Ψ) and rate of photosynthesis was found important to identify drought tolerant form/acc in coconut.

COCONUT EMBRYO CULTURE: CO₂-ENRICHMENT AND ROOT AERATION FOR IMPROVED SEEDLING ESTABLISHMENT

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Embryo culture is an important tissue culture procedure used in the international exchange of coconut germplasm and for the production of plantlets for high value, mutant coconut types that cannot germinate from seed in nature. A major problem with the presently used hybrid embryo culture (HEC) protocol is that the seedlings produced *in vitro* have a very poor rate of establishment when transferred to soil, *ex vitro*. This weakness in the HEC protocol means that many potentially valuable plants are lost. The present study shows that the early growth and establishment rate of *in vitro*-produced coconut seedlings can be improved by a) using auxins to promote root initiation, b) increasing the CO₂ concentration in the atmosphere that surrounds the seedlings to promote photosynthesis, and c) using a medium that increases aeration to the roots and aids the transfer of the seedlings to soil without significant root damage. The use of auxins (5.4 μ M NAA and 4.9 μ M IBA) and CO₂ enrichment (1 600 ppm) increased *ex vitro* seedling survival from 20 to 90 %. Under this CO₂ treatment, seedlings could be raised photoautotrophically (without sucrose) or photomixotrophically (with low levels of sucrose; 14.6 to 43.8 mM). The photoautotrophic system was considered to be the best option as the photomixotrophic system produced some plants that suffered from fungal and bacterial contamination, presumably encouraged by the

presence of sucrose, which resulted in the death of some plants. The use of vermiculite as the rooting medium for raising the *in vitro*-produced coconut seedlings increased seedling establishment rates, *ex vitro* from 20 to 90 %. This rooting medium not only provided for better root aeration but also prevented the need to cut roots during the transfer stage to soil. The improved system for raising embryo-cultured coconut seedlings is now being trialed in four countries, using several varieties, before being recommended as an improvement to the internationally recognized HEC protocol for coconut

**EMBRYO TRANSPLANTATION AND *EX VITRO* GERMINATION
FOR GERMPLASM EXCHANGE AND THE PRODUCTION OF HIGH
VALUE, ENDOSPERM MUTANT COCONUTS**

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A new and innovative technique has been developed for the establishment of coconut palms, from isolated zygotic embryos. The method uses an embryo transplantation step to a surrogate parental nut followed by *ex vitro* germination. This new technique is an alternative method to the slow, inefficient *in vitro* embryo culture technique that has been used for international germplasm exchange and conservation programs for many years. The new approach is simple and cheap to undertake. In the latest form of the technique, embryos are carefully removed from the donor nut, either as individual embryos or in an enclosing endosperm plug, using aseptic protocols. At this point in the procedure the embryos can be moved nationally or internationally using a series of previously published germplasm exchange protocols. At the destination base, similarly prepared surrogate fruits are used to receive the isolated embryos or endosperm plugs. The surrogate nuts, with the transplanted embryos, are then allowed to germinate naturally, under protected environmental conditions. The first batch of embryo-transplanted coconut seedlings using this technique has now been established in soil. In addition to the international and national exchange of germplasm, this technique is now being evaluated for the multiplication of high value, mutant coconut types, having a non-functioning endosperm (*viz.* makapuno, kopyor) and unable to germinate in nature.

**THE USE OF BIOTECHNOLOGY FOR CONSERVATION AND
DISSEMINATION OF COCONUT GENETIC RESOURCES: AN
ASSESSMENT OF THE IRD/CIRAD CONTRIBUTION**

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An assessment of twenty one years IRD/Cirad involvement in coconut (*Cocos nucifera* L.) biotechnology is presented. Research towards somatic embryogenesis and its mastering for clonal propagation of élite trees, *in vitro* conservation for short-, medium- and long-term through cryopreservation and its management and use for germplasm exchange is described. The high recalcitrance of coconut to *in vitro* culture has influenced the different directions of research. The different bottlenecks that appeared at various stages have stimulated the development of an international collaborative research programme between several Institutes, where IRD/Cirad has played an active role. Recent preoccupations relating to safe exchange of coconut germplasm, because of outbreaks of devastating diseases such as lethal yellowing, have reinforced the COGENT collaboration between coconut growing countries and Institutes such as IRD/Cirad.

Technical Session IV – Part 1

**Soils and Plant Nutrition, Agronomy and
Agric. Economics**

Session Chairman –

**Dr. U P de S Waidyanatha
Former Chairman
Coconut Research Boards**

COCONUT CULTIVATION UNDER DRIP IRRIGATION: INDIAN EXPERIENCE

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In India 90% of water available, is used for Agriculture. There is high demand for irrigation water and to increase the water use efficiency for agriculture micro irrigation techniques should be practiced. The total area covered under drip irrigation in India is 355,400 ha. Out of which plantation crop occupies only 16.9 per cent. Isotopic studies indicate that 0.75 m to 1.25 m away from the bole of the coconut basin is the active absorption zone where emitter should be placed for better use of the applied water. A minimum of 15 to 20 per cent of the active root zone should get wetted to absorb the water required by palms. Concentration of the fine roots was more in the wetted area of the drip-irrigated palms compared to the palms where basin irrigation was practiced. Palm irrigated at the rate of 33 per cent of pan evaporation (E_o) showed more stress, indicated by stomatal conductance and transpiration rate, than that of palms irrigated at the rate of 66 and 100 per cent E_o . Net photosynthesis ratio was high in the palm grown on laterite soil with drip irrigation compared to that grown on sandy soil. Nut yield recorded at 66 and 100 per cent of E_o through drip or basin irrigation was not statistically significance. Drip irrigated palms with mulch recorded high soil moisture content compared to drip without mulch. In Karnataka and Tamil Nadu palms irrigated with 100% of E_o through drip recoded higher yields. The cash flow analysis indicated that the benefit cost ratio (BCR) in the drip irrigated coconut garden was 2.02 as compared to 1.68 under basin irrigation and 1.07 in rainfed gardens.

**EFFECT OF ORGANIC MANURES ON THE MICROBIOLOGICAL
STATUS AND SOIL ENVIRONMENT OF COCONUT LANDS IN SRI
LANKA**

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One method to increase coconut production in Sri Lanka, would be wide spread use of chemical fertilizer or organic manure. Organic manures are important sources of plant nutrients which help in sustaining soil fertility and productivity, especially in a perennial crop like coconut. Hence the aim of this study was to evaluate the microbiological status and assess the soil quality in different types of coconut soils in Sri Lanka as a result of application of organic manure. To assess the changes in the microbiological and other environmental properties of soils after amendment with organic manure, six different soil series viz, Andigama, Kuliypitiya, Boralu, Ambakelle, Weliketiya and Pallama were considered. Cattle manure at the rate of 35 kg and 1.2 kg of muriate of potash per palm were applied to the experimental palms. Soil sampling was carried out at two monthly intervals, after manure application. Samples were taken 1 m away from the base of the palm at 0-15 cm depth. Most of the soil series showed high values in microbiological and other properties during the 2-4 months after manure application and thereafter a decreasing trend occurred. Twelve month after establishment of the experiment, Weliketiya soil series showed the highest increase in number of total bacterial colonies, biomass N and N mineralization as 117%, 285% and 498%

respectively over the control. The number of total fungal colonies showed highest increase (98%) in Pallama soil series. Ambakelle soil series showed the highest increase (454%) in CO₂ evolution over the control and biomass N was the highest (153%) in Boralu soil series. Soil moisture level was increased in organic manure applied soils, while bulk density and penetration were low in organic manure applied soils, which benefited the coconut palms. This study clearly showed that organic manure has improved the microbiological status and soil environment. The microbiological mediated process, showed variation among the soil series according to their texture and locations.

**MICRO-NUTRIENT STATUS OF COCONUT GROWING SOILS IN
SRI LANKA AFTER APPLICATION OF ORGANIC MANURE
AND NPK FERTILIZER**

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Currently, coconut cultivation in Sri Lanka is largely carried out either only with NPK fertilizer application or without fertilizer at all. This practice may lead to micro-nutrient depletion in coconut lands, an aspect which has not been intensively studied so far. Recent reports on suspected boron, copper and zinc deficiency prompted intensive investigation on current micro-nutrient scenario in coconut lands of Sri Lanka. The present study aims at determination of the micro-nutrient status of coconut plantations in major coconut growing soils in relation to organic manure and inorganic NPK fertilizer application carried out during past ten years. The experimental sites were selected to represent some widespread soil series in Sri Lanka. The sites were selected to include three types of fertilizer treatments; i.e., treated with organic manures, inorganic fertilizers and no fertilizer for the past ten-year period. Soil samples from 0-25 cm and 25-50 cm depths to represent both the manure circle and the center of square and coconut leaf samples from 1st, 6th and 14th fronds were taken from randomly selected sites. In the soil samples, DTPA extractable Fe, Mn, Cu and Zn contents were determined. Leaf samples were analyzed for total Fe, Mn, Cu and Zn contents by wet digestion with 1: 4 concentrated HNO₃ and HClO₄ acid mixture. The results showed that, despite fertilizer application practices, there was no significant depletion of Fe, Mn, Cu and Zn in the coconut soils but Mn, Cu and Zn status of the coconut palms were lower than the sufficiency level which demand more detailed investigations.

EFFECT OF BORAX APPLICATION ON THE PERFORMANCE OF COCONUT SEEDLINGS

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There is increasing incidence of boron deficiency in coconut palms in the root(wilt) affected tract in the southern districts of Kerala, India. An earlier survey in this tract indicated that 19-25% of the palms had boron deficiency symptoms. The symptoms manifested due to boron deficiency in coconut palms include malformations in leaves as well as in the nuts resulting in stunted growth and low productivity. A field experiment was conducted at Central Plantation Crops Research Institute, Kayankulam to study the effect of different doses of boron on deficiency symptoms and the nutrition of coconut seedlings. The results revealed that the seedlings which had boron deficiency symptoms showed recovery with the boron application. Among the different levels of borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$) tried on coconut seedlings, application of 300 g borax per seedling per year in two equal splits was found effective to achieve recovery and to improve the growth of the young seedlings. The seedlings treated with borax showed improvement in growth parameters such as girth at collar, annual leaf production and total functional leaves and boron content in leaf tissues.

RESPONSE OF COCONUT TO DRIP IRRIGATION IN THE SOUTHERN TROPICAL LOW RAINFALL ZONE OF INDIA

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A field experiment was conducted in red sandy loam soil of the Coconut Research station, Aliyarnagar, Tamil Nadu, India to find out the water requirement of coconut palm. In this southern tropical zone where the annual rainfall is less than 1000 mm, irrigation is required throughout the year for successful cultivation of coconut. The irrigation treatments comprised: no irrigation, three drip irrigation levels equal to 33%, 66% and 100% E_o (pan evaporation) and basin irrigation with 40 mm of water at IW/CPE ratio of 1.0. The results of the study from 1998-99 to 2001-02 revealed that drip irrigation influenced the annual leaf production rate, functional leaves, bunches and female flower production in coconut. The mean nut yield increased from 71 under no irrigation to 147 nuts palm⁻¹ year⁻¹ under drip irrigation. Palms with drip irrigation equal to 100% E_o and basin irrigation produced a mean nut yield of 147 and 146 nuts palm⁻¹ year⁻¹ respectively. Higher levels of drip irrigation increased the leaf N content of the palm from 1.51 to 1.90% and decreased the leaf K percent. Drip irrigated palms equal to 100 % E_o recorded maximum net income of Rs.45518/- ha⁻¹ (Indian Rupees) and benefit cost ratio of 2.11. The pay back period was 4.73 years for drip irrigation at 100% E_o , whereas it was 6.16 and 5.23 years for 66% and 33% E_o respectively. The mean water requirement of the palms receiving 100, 66 and 33 % E_o were 13591, 8970 and 4485 liters palm⁻¹ year⁻¹ respectively and contribution through rainfall was 5848 liters palm⁻¹ year⁻¹.

NUTRIENT BUDGET FOR COCONUT (*COCOS NUCIFERA*) BASED RESTRICTED SCAVENGING POULTRY PRODUCTION SYSTEM

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Coconut (*Cocos nucifera*) is a poor land user, utilizing only 25% of land area. The inefficient resource use and low farm productivity have resulted in low farm income from coconut monocultures. Soil degradation and lack of attention to soil improvement have further reduced the coconut production aggravating the issue of low profitability. Integration of livestock in coconut plantations is a suitable option, not only to increase the productivity but also to enhance the soil quality. Semi-intensive restricted scavenging poultry production system was evaluated for higher productivity and sustainability of soil in coconut plantations. This paper discusses the whole farm nutrient balance of coconut- poultry production system with the emphasis given for three poultry crosses/breeds evaluated for higher productivity. Nutrient budgets were calculated for three systems to evaluate the potential for reducing cost of fertilizer for coconut. Three coconut poultry production systems with CPRS Brown strain (Central Poultry Research Station) and two of its crosses with indigenous populations consisting of 50% indigenous blood level (I50), and 75% indigenous blood levels (I75) were assessed for nutrient balance of the systems. One-month-old chicks were introduced to the system. Each group was divided into three replicates (25 birds each) and respective enclosures

under coconut were assigned at random. They were allowed to scavenge within the enclosure (16m² per bird) but were supplemented with a formulated ration at the rate of half of the feed requirement irrespective of growth stage. Daily feed consumption, weight gain (monthly) egg production, dung voided (weekly) were collected during the experiment period. Three systems showed a positive balance for N (180-192 kg/ha/yr) and P (71 -74 kg/ha/yr) while K was in negative balance. The commercial breed (CPRS) showed fewer surpluses of N & P due to higher egg production in comparison to its crosses with indigenous blood. The total N and P requirement (Nut production- 90 nuts/year/palm) was met from the external inputs supplied for poultry and poultry droppings. Results also suggested that K requirement has to be supplemented through external inputs at the rate of 1800 g of MOP per palm per year for the productivity of 90 nuts/ year / palm while supplementation of 800 g of MOP is sufficient to meet the palm nutrient requirement for coconut lands with 60 nuts per palm per year, saving the cost of fertilizer by 70% per hectare of coconut.

AN ANALYSIS ON PHYSIOLOGICAL CONSTRAINTS FOR ACHIEVING YIELD POTENTIAL IN COCONUT

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A wide gap exists between potential and achieved yields in coconut. It is important to know the physiological efficiency of coconut for yield so as to look for germplasm with specific traits or to engineer the crop to overcome the bottlenecks in achieving near potential yields in coconut. With this in view, a study was conducted to analyze the physiological constraints for high yield in coconut. In a group of 15-year old coconut cultivars and hybrids, photosynthetic efficiency, water use efficiency, dry matter production and partitioning varied. The mean photosynthetic rates (P_n) were higher in hybrids than in talls. Interestingly, the physiological water use efficiency ($WUE = P_n/E$; E = transpiration rate) is almost similar in both hybrids and talls. Analysis of gas exchange data indicates that the physiological WUE is strongly correlated to the P_n rates. Low P_n rates during severe summer lead to reduced dry matter production thus limiting the yields. The canopy size and P_n rates are positively correlated with total dry matter (TDM). As, TDM has a positive correlation with harvest index (HI) for copra, undoubtedly, high TDM production is important obtaining high copra and nut yields. Since the partitioning of dry matter to copra is proportionate to its partitioning to nuts as such, it is desirable to look for high HI for copra. Analyses indicated that P_n rate is the major limiting factor in coconut under well-managed conditions. The study highlights that coconut is a source limited crop and efforts are needed

to increase the photosynthetic efficiency. This suggests the need to improve the carboxylation efficiency of coconut by engineering for efficient RUBISCO. Possibly one should also look for leaf and canopy structure, which favours high Pn. Apart from this, selection for high HI for copra and high number of nuts is desirable in breeding for high copra yields and high tender nut yields, respectively.

**DETERMINANTS OF EXPORT DEMAND OF COIR FIBRE
AND COIR FIBRE PRODUCTS IN SRI LANKA:
IMPLICATIONS FOR EXPORT PROMOTION**

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Although Sri Lanka is considered as the world market leader of exports of brown coir fibre and its products, the country was able to maintain this market leadership only until 1999. During the period 1992-2001, Sri Lankan share of coir fibre and coir products in the world market has decreased from 66% to 43%. With this background, this paper investigates the factors affecting the export demand of two types of coir fibre (mattress and bristle) and three intermediary coir products (twisted fibre, coir yarn and twine) in order to derive implications to promote exports of coir fibre products. Based on time series of data for the period 1980 to 2000, derived demand functions were estimated for each coir fibres and intermediary coir products using 2SLS procedure. Own price of inputs, price of substitute inputs, price of products, one-year lagged coconut production and time trend were used as explanatory variables. It was revealed that product (mattress bedding) price and a year lagged coconut production had positive effects on the mattress fibre exports with negative time trend. For bristle fibre

exports, both product (brush) price and one year lagged coconut production had positive influences but the time trend was found to be negative. Although substitute (sisal) price showed a negative relationship with the bristle fibre export volumes, this was not found to be statistically significant. None of the explanatory variables used in estimating the derived demand for twisted fibre and coir yarn were found to be significant although coir yarn had a significant negative time trend in exports. All coir fibre and intermediary coir products showed insignificant export price elasticities of demand implying that export volumes were not responsive to export prices. The export prices of coir and intermediary coir products had no effect on their export performance but the national coconut production and the prices of final products showed a positive effect. Development of new products and implementing programmes to boost national coconut production are recommended for export promotion of coir fibre and allied products.

Technical Session IV - Part II

**Soils and Plant Nutrition, Agronomy
and Agriculture Economics**

Session Chairman -

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POVERTY REDUCTION IN COCONUT GROWING COMMUNITIES

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Coconut farmers are very poor and are living below the poverty line mainly because most of them produce and sell low-value copra (dried kernel) or whole fruits which give them marginal incomes. IPGRI and its International Coconut Genetic Resources Network (COGENT) believe that these constraints can be overcome through a sustainable livelihoods intervention. In collaboration with national partner institutions and community-based organizations, IPGRI and COGENT are testing the hypothesis that coconut farmers need not be poor by developing and testing the viability and sustainability of diversity-linked village-level income generating technologies in 24 coconut growing communities in eight Asia-Pacific countries (Bangladesh, India, Sri Lanka, Philippines, Vietnam, Indonesia, Fiji and Papua New Guinea). Initial results indicate that the hypothesis is true. To date, the following have been achieved: twenty four community-based organizations in eight countries with 5,132 members were established and strengthened; 5,738 farmers and women were trained on various income generating activities; 32 community-managed coconut and 13 multi-purpose seedling nurseries established; 52,535 coconut seednuts sown and 52,712 coconut seedlings from farmers varieties and introduced high-value varieties were planted and conserved on farm; 1,203 farmers and women involved in coconut-based livestock production trials, 3,739 in intercropping trials, 1,369 in production of high-value coconut products; and 75 public awareness articles published and disseminated.

**WOMEN'S INCOME GENERATION FROM COCONUT –BASED
COTTAGE ACTIVITIES AND ITS CONTRIBUTION TO THEIR FOOD
SECURITY IN TWO RURAL POOR COMMUNITIES IN SRI LANKA**

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Rural women play an important role in household income generation through coconut-based cottage activities. Their role in household food security and nutrition are also associated with access to income. This study focuses on the women's income generation from two specific coconut-based cottage activities and its contribution to their food security in a sample of women in two selected rural communities in Sri Lanka. The objectives of this study are to examine the factors influencing the proportion of women's income generation from coconut bract handicraft making and coir yarn spinning and to identify the factors influencing their daily caloric intake. To realize these objectives, two equations explaining the women's proportion of income generation and their daily caloric intake were established and econometrically estimated. The results suggest that the income generated from the two specific coconut-based activities significantly contributed to the women's share of income to the total household income. Also, their age, number of years of formal education, total working time, total members in the household, the training they get on these occupations are other factors that significantly contributed to the proportion of

women's income generated from coconut bract handicraft making and coir yarn spinning. Women's daily income from these coconut-based activities is a major determinant to obtain a satisfactory energy intake for them. In addition, their age, the food expenditure share, total members in the household and the caloric contribution made from coconuts are other contributory factors for the level of daily caloric intake of these women. Thus, coconuts are not only a source of income but also an important source of energy for the poor rural women in these communities.

**AN ANALYSIS OF THE PATTERNS OF EXPENDITURE ON
COOKING OILS OF URBAN CONSUMERS IN COLOMBO**

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Even though in the past Sri Lankan cooking oil market was dominated by coconut oil, at present, imported cooking oils have captured a significant portion of it. Increasing amounts of these imported oils with a cholesterol free label have created severe competition within the local oil market. Therefore, this study was conducted with a view to examine the patterns of expenditure on cooking oils across different income groups of local consumers and to identify the socio-demographic factors that influence the level of expenditure on cooking oils. Data were collected from 150 randomly selected households from three housing schemes within the Colombo municipality limits. Results of the study indicated that the patterns of expenditure on coconut oil between low- and high-income groups are significantly different. Ethnicity, level of education and family size showed a positive influence and the household's health consideration factor showed a negative influence on the level of expenditure on cooking oils. The study shows that marketers should focus different income groups and give more weight to health issues in promoting the use of coconut oil.

**PERFORMANCE EVALUATION OF VIRGIN COCONUT OIL
EXPELLING SYSTEM THROUGH A FIELD TRIAL**

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Most commercial grade coconut oils for edible, cosmetic and industrial purposes are made from copra. The unrefined coconut oil extracted from copra is not suitable for consumption and must be purified / refined, bleached and deodorised. It has been established that copra dried above the 'safe' moisture content limit for prolonged period and smoke drying of the copra with soot laden flue gases from coconut shells, which constitute the traditional process of copra making in Sri Lanka, leads to formation of Aflatoxin and Poly Aromatic Hydrocarbon Compounds in the copra and hence in the coconut oil derived from same. Virgin Coconut Oil derived from fresh coconut kernel has been established to overcome the above problems. The oil is pure, natural and crystal clear having the distinct aroma and taste of coconuts. The National Engineering Research & Development Centre (NERDC) of Sri Lanka after having perfected the process in the year 2000 subsequently developed a medium size Hydraulic Jack operated oil expeller and a complimentary Rotary dryer to meet the demands of entrepreneurs. Coconut Research Institute (CRI) of Sri Lanka, under its Asian Development Bank funded project coordinated by the

Coconut Genetic Resources Network (COGENT), collaborated with NERDC to test the above Coconut Oil Expelling System through a field trial at Wilpotha, a coconut growing area in the North Western Province. The Hydraulic jack operated oil expeller was tested for optimum oil yield, extraction efficiency and the Rotary dryer was tested for its economical capacity, fuel consumption of the Heat Exchanger, rate of drying, drying efficiency. The gross margin analysis was performed to evaluate the profitability of the virgin oil expelling system. Results revealed the performance of the system mainly including the drier and the expeller was satisfactory. The economical capacity of the drier is scraped coconut of 40 nuts at a time and within 102 minutes required dryness can be achieved. Trials on oil extraction efficiency of the Hydraulic press showed that about 55% oil can be extracted from the dried coconut and about 75% oil recovery can be achieved. Quality of Virgin coconut oil produced from this system is conforming to Sri Lankan Standards. The profitability analysis of this says that the producer could generate a net profit of SLR 86.50 per litre of oil.

**INCOME GENERATION FROM ALTERNATIVE COCONUT-BASED
HIGH VALUE PRODUCTS AND THEIR PROFITABILITY IN RURAL
POOR COMMUNITIES IN SRI LANKA**

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Coconut provides ample opportunities to generate incomes for rural poor. However, many traditional coconut-based activities generate marginal incomes for producers due to various constraints faced by them. The project on "Poverty reduction through coconut-based interventions" introduced several alternative coconut-based high value product manufacture for income generation among the poor people in three selected coconut-based communities. A majority of the members of the selected communities (50%) receives less than 1 USD income per day. This study was done to assess the profitability of few selected new coconut-based high value product manufacture carried out by the people of these communities. Data were collected from the beneficiaries, who perform each high value production activity. Gross margin analyses were done to examine the profitability of each activity. Among the alternative coconut-based high value productions, husk chip cutting, coconut shell and bract handicraft making, virgin coconut oil making, ekel broom production are found to be the highly rewarding occupations. The income generated from all these activities exceeds

SLR 300 per man-day, suggesting a higher return for rural poor, who engage in these endeavors. These results clearly indicate that these newly introduced coconut-based product manufacture is profitable, generating a substantial profit margin to the producers than the traditional coconut-based income generation activities. Hence, the selected coconut-based high value products manufacture can be considered as promising approaches for rural poor to enhance their income.

COCONUT – A MEANS OF INCREASING INCOME FOR RURAL WOMEN

Kala Peiris De Costa
Siyath Foundation, Sri Lanka

Coconut one of the three main cash crops of Sri Lanka has also provided a means of livelihood to many families living along coastal areas of the island. As a self-employment avenue women in these families have produced yarn from time immemorial. As the occupations in this industry are strictly demarcated between the sexes the lot of women undertaking the lower strata of jobs has always been much harder than that of men. Since the late '70s with the introduction of open economic policies and migration to towns or abroad in search of jobs have resulted in higher incomes. Export of diversified finished coconut based products is a new feature that requires maintaining quality standards and keeping time schedules. Although NGOs intervention to institute savings, credit, collective buying and selling have had a salutary effect-structural adjustments, new policies also take their toll and the poor are engulfed in a losing battle to keep the wolf of hunger from the door. A section of the community most affected by these changes has been the coir yarn making women who are at the mercy of both fibre and yarn traders. Siyath Foundation, a NGO working for the upliftment of these communities, has been supported in many ways by the Coconut Research Institute of Sri Lanka. Through developing and training in new technologies (among other strategies) CRI seeks to demonstrate the tremendous potential of coconut for increasing incomes of the rural poor in the coastal areas. Other supplementary aspects covered are maximizing land profitability,

promoting integrated farming and livestock keeping. The most recent Siyath's pilot project, supported by CRI included training in and introduction of coconut varieties, other crops related to coconut production, animal husbandry as a supplementary activity and awareness creation of other related industries. Cows, goats and poultry were distributed to 34 families. Coconut and pepper plants pineapple and other fruits and vegetable products together with fertilizer and training in planting seedlings were other facilities provided. The clientele expanded from women to youth and families. The collective actions involved resulted in improved family relations and social harmony in the community. Higher economic returns induced families to work harder. A noticeable change is seen in the community bringing about an inner empowerment in each individual as well as in communities

Technical Session V

Crop Protection

Session Chairperson -

Prof. Jayanthi Edirisinghe

Department of Zoology

University of Peradeniya

CHEMICAL CONTROL OF COCONUT "LIXAS" AND LEAF BLIGHT DISEASE OF COCONUT

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A disease complex formed by three fungi are responsible for the reduction in assimilating leaf area and consequently for the low production of coconut in Brazil. "Lixa Pequena" or small verrucosis, caused by *Phyllachora torrendiella* Subileau, Lixa Grande also known as large verrucosis i caused by *Sphaerodothis acrocomiae* (Mont.) von Arx et Müller and *Lasiodiplodia theobromae* The experiment was conducted in the county of Neópolis, State of Sergipe on a green dwarf coconut plantation, 3 and 6 years old in a zone most affected by "lixas" and leaf blight. In the first trial the more efficient fungicide was cyproconazole reducing the number of stromata in 70%.The efficiency for the control of "lixa pequena " was different, better performance was obtained with difenoconazole (63% of stromata reduction), The best result for leaf blight reduction was obtained by the utilization of Folicur (tebuconazole) with the reduction of 37% of disease incidence but was not confirmed when the plants were in production. In the second experiment the best results were obtained by the use of Trifloxystrobin + Propiconazole, with a disease index of 29%

COCONUT PHYTOMONAS WILT CHARACTERIZATION AND INTEGRATED CONTROL

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Phytoplasma wilt is a lethal disease of coconuts transmitted by insects of the Pentatomidae family. In order to verify the effect of integrated control on the incidence of the disease, one experiment was installed in Una, Bahia, a region where the disease occurs naturally. A group of 820 plants had the surrounding weeds slashed, regular circle weeding, cleaning of old coconut leaves, removal of infected plants, gathering of *Lincus lobuliger* Bred in the cut coconuts and monocrothophos spraying, while another group with the same number plants remained untreated. The coconut was considered infected by *Phytoplasma* when showing leaf yellowing in an ascent way and browning of the inflorescence. The diagnosis was completed by microscope examination of infected tissue. The observations were made monthly from June/96 to July/97. At the end of 14 months, the number of dead plants in the treated group was 11 (1.3%), while the untreated group lost 39 plants (4.7%). The Chi square test results ($X^2_{0.05} = 16.17$) lead to the conclusion that the treatments were different.

EFFECT OF *PAECILOMYCES LILACINUS*, *PASTEURIA PENETRANS* AND VAM ON THE GROWTH OF COCONUT SEEDLINGS INFESTED WITH *RADOPHOLUS SIMILIS*.

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The burrowing nematode, *Radopholus similis* causes serious damage to coconut. Lesions and rotting of roots, defoliation and poor yield are the symptoms due to this nematode attack. Though the application of nematicides is effective in reducing the nematode population, it destroys the beneficial soil fauna. Introduction of Vesicular Arbuscular Mycorrhizal (VAM) fungi can protect the coconut seedlings from nematode invasion. Investigation was carried out in 1994-1998 to determine the effect of biocontrol agents (BCA); *Pasteuria penetrans*, *Paecilomyces lilacinus* and some Vesicular Arbuscular Mycorrhizal fungi on the growth of *R. similis* infested coconut seedlings. The application of biocontrol agents viz. *P. penetrans*, *P. lilacinus* and VAM fungi reduced the nematode multiplication effectively while ameliorating the ill effects caused by the nematode. These biocontrol agents were more effective when they applied together than individual applications. Prior mycorrhization of plants by inoculation of VAM fungi at nursery level enhanced the plant growth. Among these BCA, *P. penetrans* was more effective in reducing the nematode population. In all treatments, prior protection of the plants with BCA either individually or in combinations was always better than their simultaneous

inoculations with the nematode, to obtain maximum reduction in the nematode population. *P. penetrans* suppressed the nematode population effectively under field conditions. *P. lilacinus* was also effective in reducing the nematode population and able to survive under field conditions for more than three years. Among VAM species *Acaulospora bireticulata*, *Glomus mosseae*, *G. fasciculatum* multiplied well under field conditions. Hence, it can be recommended that the introduction of these three VAM species along with *P. lilacinus* and *P. penetrans* into the sterile potting mixture in poly bags and also into planting pits at transplanting to protect the roots from nematode infestation and for the better establishment of transplants in field. Since these organisms were found to multiply and survive under field conditions for more than three years, they need to be introduced to the root zone of perennial crops after every three to five years. This is the first report on multiplication and sustenance of VAM, *P. penetrans* and *P. lilacinus* in roots and rhizosphere of coconut, and their beneficial effect in suppressing the population of *R. similis* under the high rainfall tropical field conditions in acidic soil.

**THE EFFICACY OF CARBOSULFAN 20 SC IN THE MANAGEMENT
OF COCONUT MITE (*ACERIA GUERRERONIS*)**

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Aceria guerreronis is the only species of eriophyid mite causing serious damage to coconut. No sustainable method of management is so far available. Even though the research on biological control is the main strategy expected for the management of this pest, only available management strategy is to use chemicals. The chemicals recommended at present have their own drawback such as less effectiveness and high toxicity. Therefore there is a necessity to screen effective chemicals. The efficacy of carbosulfan SC 20 was evaluated under field conditions. Carbosulfan SC 20 was tested with three application methods viz. root feeding (10 ml, 20 ml/palm) trunk injection (10 ml, 20 ml/palm) and crown spraying (2ml/l, 4ml/l) in comparison with spraying sulphur (0.1 % and 0.2%). Mortality of mites and reduction in the damaged nuts in the new bunches was considered. Application of Carbosulfan by root feeding at monthly intervals for period of two months resulted in significantly high mortality (78 %) in the population of coconut mite and reduction in percentage damaged nuts from 87% to 16%. Mortality caused by spraying of carbosulfan was also significantly high (67%) over the control and the reduction in percentage damaged nuts from 85% to 29%. Large scale testing of marshal, its effect on predators and the assessment of residues in edible parts is warranted before making a recommendation.

A METHOD FOR *IN VITRO* CULTURE OF COCONUT MITE, *ACERIA GUERRERONIS* KEIFER (ACARI: ERIOPHYIDAE) IN IMMATURE LEAF TISSUES OF COCONUT (*COCOS NUCIFERA* L)

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The coconut mite (*Aceria guerreronis*) was first reported in the state of Guerrero in Mexico in 1965. In Sri Lanka, it was first reported in Kalpitiya area in December 1997. By 1999 the damage developed to an outbreak level in Puttalam District. A crop loss up to 30% has been estimated in the global scenario. Due to the difficulties in conducting both laboratory and field investigations, *Aceria guerreronis* has not received due research attention due to its biology as well as the nature of the host. An effective and long lasting control method has not been developed yet. Published information on research conducted in the past on basic biology and in vitro culture methods of coconut mite is very rare. Therefore, the present study was carried out to identify a suitable culture medium for laboratory rearing of coconut mites and to study the life cycle of the pest. To achieve these objectives, two agar based media, wax coated perianths and immature leaf tissues were evaluated for rearing mites. Among the media, immature leaf tissue pieces medium was the best medium for the survival. Leaf tissues obtained from meristematic region of 2 months old seedlings showed to provide optimum conditions for maintaining laboratory colonies. With

this method twelve-fold increase of the number of mites in a colony could be achieved within a period of three to four weeks. This rearing method could be used to study the various aspects of the biology of coconut mite. Using the developed method, the life cycle was studied in the laboratory. Life cycle consists of six stages; egg, larva, nymphochrysalis, nymph, imagochrysalis and adult. Mean length of the life cycle from egg to adult was 9.7 days at 27° C. Length of the body of the mite developed from 82.5 µm in the larval stage to 195 µm in the adult stage. The findings of the present study provide some useful information on the biology of coconut mite that helps to design and conduct other research towards the management of this pest.

**APPLICATION METHODS OF Zn AND THE EFFECT OF MACRO-
AND MICRO NUTRIENT APPLICATIONS ON THE EXPRESSION OF
LEAF SCORCH DECLINE SYMPTOMS IN COCONUT (*COCOS
NUCIFERA L.*)**

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Leaf Scorch Decline (LSD) affected palms exhibit a deficiency in Zn and a considerable amount of root decay. Therefore, the study was conducted with the objectives of determining (i) the best feasible method to apply Zn (ii) to investigate the effect of Zn on the recovery of LSD symptoms, and (iii) to determine the effect of macro and micronutrients application on greening of the canopy and new root formation. Mild and moderate LSD affected palms and healthy palms were used for the study. Root feeding (25 ml of 1% ZnSO₄), trunk feeding (20 ml of 5% ZnSO₄), leaf spraying 1% ZnSO₄ and leaf axile application (12.5 ml of 8% ZnSO₄) were tested as treatments for application of Zn. Post-treatment Zn concentration in root, trunk and leaves were analysed. Five liters of macro and micro nutrient solution was sprayed to canopy as total nutrient application. Root feeding or trunk feeding of Zn did not show a significant improvement of Zn levels in leaves. However, there was an accumulation of root fed Zn in the roots without translocating to trunk and leaves in both healthy and LSD affected palms. Therefore, it seems that there is a problem of translocating Zn through the vascular system of roots. When consider the spraying and the axile application of Zn, both methods increased

the Zn levels significantly in healthy and LSD-affected palms. Therefore, leaf treatment, either by spraying or axile treatment found to be the best method for application of Zn. It is too early to observe the effect of nutrient application on new root formation and the expression of leaf scorching. However, following nutrient applications, the greenness of the canopy of LSD- affected palms was improved.

**DEVELOPMENT OF VARIETIES OF COCONUT (*Cocos nucifera* L)
RESISTANT/TOLERANT TO ROOT (WILT) DISEASE**

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Root (wilt) is a very serious disease of coconut in Kerala. The disease is caused by phytoplasma and transmitted by insect vectors. Development of resistant/tolerant varieties is considered to be a possible solution for this disease. Breeding for resistance to this disease is being implemented since 1987. Studies revealed that Chowghat Green Dwarf (CGD) variety has higher level of resistance to root (wilt) when compared to other varieties. In the disease-hot spots, in the midst of heavily disease-affected palms, disease-free palms of West Coast Tall (WCT), CGD and Chowghat Orange Dwarf (COD) are found and these elite palms constituted the base material for the breeding programme. Currently 69 WCT, 85 CGD and 25 COD palms, located in farmers' plot are included in the crossing programme. The following crosses are being carried out: WCT (self/*inter-se*), WCT X CGD, CGD (self/*inter-se*), CGD X WCT, COD (self/*inter-se*), and COD X WCT. A total of 2725 progenies of various crosses, planted since 1991, are being evaluated for yield and disease resistance. After 12 years of evaluation, WCT (open pollinated) progenies showed 75% disease incidence whereas WCT (self) and (*inter-se*) showed only 57% disease incidence indicating the superiority of full sib progenies to half sibs for resistance to root (wilt). CGD X WCT hybrid planted during 1991 showed 65% disease incidence and gave a cumulative average

yield of 78 nuts/palm/year. It indicates that CGD X WCT hybrids gave satisfactory yield even when then they are diseased and are tolerant to root (wilt). Four seed gardens consisting of 6472 artificially pollinated seedlings of WCT, CGD and COD have been established in five locations for large-scale production of root (wilt) resistant/ tolerant planting material.

ASSESSMENT OF PEST/DISEASE INFESTATION ON COCONUT AND YIELD LOSS

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One of the major limiting factors of coconut production in India is the incidence of pests and diseases. Data on incidence of pest/disease and resulting yield loss are necessary for research prioritization and technology intervention but are not collected/reported along with the official statistics on crops. The required information is therefore generated by conducting sample surveys. Results on earlier surveys conducted by CPCRI on coconut pests and disease were made use of in analyzing their usefulness for applications in similar situations. The organizational aspects of surveys such as criteria for stratification, preparation of sampling frame, selection of units, construction of estimators, organization of field work etc. were examined in relation to suitability under respective contexts.

Technical Session VI

Coconut Process Research

Session Chairperson –

Dr. Nandani Ediriweera

Head, Food Technology Division

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**NEW TECHNOLOGIES OF COCONUT PROCESSING - Part I:
PROCESS FOR DEFATTING COCONUT MEAT (WET & COLD
PROCESS)**

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New Technologies of Coconut Processing recently have been developed at Coconut Research Institute Sri Lanka in co-operation with gtz (Society for Technical Cooperation) and ADB (Asia Development Bank). The basic object is to propose an efficient and gentle process for removing the fat from the edible component of the coconut meat. By means of a very simple but ingenious technique endosperm of coconut can be separated succesively into Coconut Skim Milk, Virgin Coconut Oil and dietetic fibre by a three step WET & COLD PROCESS. In another DRY PROCESS (see *Part II*) it was demonstrated how to obtain a Virgin Coconut Oil and a high protein coconut flour from dried coconut endosperm. Both technologies in Coconut Processing open a wide window for new Coconut products which enable to take advantage of all nutritive components of the coconut in the future. Based on both process-technologies the production of the following edible Coconut-Products is now realizable: Coconut Skim Milk, Coconut Milk-Jellies, Coconut Milk – Yoghurt, Diet-Vegetable Coconut Spreadcheese (with / without dietetic fibre), Instant Coconut Skim Milk Powder, Virgin Coconut Oil, Diet Coconut Fibre (suitable as food additive) or Lignin free Cellulose Fibre for technical purpose (filters and paper making).

**NEW TECHNOLOGIES OF COCONUT PROCESSING - Part II:
PROCESS FOR Production of VIRGIN COCONUTOIL and Low Fat /
High Potein Coconut Flour from coconut kernel**

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New Technologies of Coconut Processing recently have been developed at Coconut Research Institute Sri Lanka in co-operation with gtz (Society for Technical Cooperation) and ADB (Asia Development Bank). An efficient and gentle process for removing the fat from the edible part of the coconut meat has been found. By implementation of a special oil expeller endosperm of coconut can be separated carefully into Virgin Coconut Oil and a low fat/high protein Coconut Flour. Together with the COLD AND WET PROCESS (see part I) both technologies in Coconut Processing open a wide window for new Coconut products which enable to take advantage of all nutritive components of the coconut. Based on both mentioned process-technologies (cold and *wet and dry process*) the production of the following edible Coconut-Products is now realizable : Coconut Skim Milk, Coconut milk-Jellies, pure Coconut milk – Yoghurt, pure Diet-Vegetable Coconut Spread cheese (with / without dietetic fibre), Instant Coconut Skim Milk Powder and Virgin Coconut Oil, Diet Coconut Fibre (suitable as food additive) and Lignin free Fibre for technical purpose (filters and paper making) are obtained as by-products.

DETECTION OF ADULTERATION IN LAURIC OILS: USE OF DIFFERENT ANALYTICAL TECHNIQUES

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Analytical methods are highly demanded to combat adulteration practices in oils and fats industry. In this study, ways of detecting adulteration in lauric oils such as palm kernel oil (PKO) were investigated using instrumental techniques such as gas liquid chromatography (GLC), reversed-phase high performance liquid chromatography (RP-HPLC), and fourier transform infrared (FTIR) spectroscopy. PKO collected from a local refinery (Malaysia) was spiked with animal fats such as lard (LD), beef tallow (BT), and chicken fat (CF) into varying proportions (1 – 20%). Unadulterated sample and its adulterated blends were analyzed by the above instrumental techniques in order to develop strategies for detecting adulteration. GLC studies showed that monitoring of fatty acid (FA) such as palmitoleic (C_{16:1}), linolenic (C_{18:3}), heptadecanoic (C_{17:0}), and arachidic (C_{20:0}) could help detection of PKO adulteration at 5% level. Application of RP-HPLC with refractive index (RI) detector can detect adulteration as low as 4% level. The FTIR spectroscopic technique indicated that animal fat adulteration even at 2% can be traced by monitoring the spectral deviations in frequency ranges of 3020 – 2995 cm⁻¹ and 975 – 930 cm⁻¹.

Technical Session VII

Technology Transfer

Session Chairman –

Dr. U Pethiyagoda

Former Director

Coconut Research Institute

**THE IMPORTANCE OF INTERACTIVE MULTIMEDIA PROGRAMS
(IMM) AS AN EFFECTIVE EXTENSION MATERIAL IN THE
COCONUT SECTOR OF SRI LANKA - AN OVERVIEW**

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Interactive Multi Media Programs (IMM) are supposed to be a modern and effective extension tool used in the world today. It combines all the media elements such as video, audio, text, photos, and animation, as the user computer interact with the program. Some contemporary researches on coconut emphasize that the need of the strengthening of the existing extension (Technology Transfer) services related to the coconut. The extension services in CRI are very limited due to the shortage staff and limited funds. Therefore both the conventional and modern concepts of extension are important to give an effective extension service to cater the needs of the coconut growers. IMM could be used as a teaching tool for extension training as well as self learning electronic book. Though there are limitations associated with IMM, such as lacking of computer facilities, it will be a promising extension tool for the Sri Lankan coconut sector in the future.

NEED FOR TECHNOLOGY PRIORITIZATION FOR IMPROVING COCONUT PRODUCTIVITY IN INDIA

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Indian coconut sector faces daunting challenges in the present era of trade liberalization and globalization. Competitiveness through higher productivity is the theme of the strategies often suggested by researchers, planners and policy makers for overcoming the problems arising from the Agreement of Agriculture on WTO. For achieving the desirable level of productivity, the role of technology is crucial in the production, processing and marketing sectors of coconut industry. Though India is one of the largest producers of coconut in the world, with an average productivity of around 6700 nuts/ha, it is also the largest consumer of coconut and its products. Due to increasing population and domestic demand for vegetable oils in India, the demand for coconut and its products is estimated to be double by 2025 AD. Strenuous research efforts for more than three decades by the Central Plantation Crops Research Institute as well as the State Agricultural Universities in the major coconut producing States of India have led to evolution of many technologies which are expected to increase the productivity in the production and processing sectors to the desired level. At the same time, for sustained growth of production and productivity a micro level, efforts are also being taken by the Transfer of Technology Network consisting of the State Department of Agriculture/Horticulture in coordination with Development Boards and

Institutional Credit Agencies. In spite of all these efforts, the growth in coconut productivity has not been sustained at the desired level. One of the major reasons this could be the lack of prioritization of technologies to be transferred and their implementation. This paper reviews the existing scenario of coconut production in major producing zones and highlights the major problems in each of the zones and prioritizes the technologies for transferring and effective implementation at micro level for achieving sustained development in coconut production sector.

**FARMER PARTICIPATORY TECHNOLOGY ASSESSMENT AND
REFINEMENT IN COCONUT THROUGH INSTITUTION-VILLAGE
LINKAGE PROGRAMME – EXPERIENCES OF CPCRI IN INDIA**

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Ensuring farmer participation in research and extension invariably enhances the extent of technology utilization at farm level. There is scope for participatory technology assessment and refinement in coconut for achieving higher productivity. Indian Council of Agricultural Research (ICAR) started a project in 1995 for Technology Assessment and Refinement through Institution-Village Linkage Programme (IVLP) under National Agricultural Technology Project (NATP). Central Plantation Crops Research Institute (CPCRI) is one of the selected centres to implement the project. IVLP is a novel front line extension programme, the implementation of which begins with the selection of a suitable village, that is followed by a detailed agro-ecosystem analysis of the selected village, diagnosing the problems of each production system and prioritising these problems; identification of technological interventions based on problem-cause relationship; the development of action plans and their implementation; and detailed socio-economic evaluation including farmers' reactions and perceptions about the interventions. This is carried out using various PRA tools and techniques. In all these stages, the active participation of farmers was ensured. CPCRI has been implementing IVLP in three villages, viz. Pady, Edneer and Nekraje of Kasaragod, Kerala with coconut as one

of the important crops in the production system of the villages. This paper, besides detailing the IVLP approach, gives an account of the participatory assessment of technological interventions relating to coconut production system such as intercropping, nutrient management and crop protection.

**EXPERIENCE IN TECHNOLOGY TRANSFER ACTIVITIES OF THE
COCONUT RESEARCH INSTITUTE**

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The Coconut Research Scheme established in 1929 with the objective of generating technologies to improve the productivity of coconut cultivation and processing sector. The foremost step was to understand problems and needs in both cultivation and processing sectors through effective interactive events with them. In view of implementing development programmes with new technologies Field Advisory Officers were appointed by the Institute for different coconut growing areas. The technical knowledge and skill of those officers were regularly updated in keeping with technological enhancement. With the formation of Coconut Cultivation Board (CCB) in 1971, the regional stations established under the CCB absorbed the Advisory Field Officers. Information regarding improved technologies released by the Institute reached growers through extension personnel of CCB or direct to growers through different need based approaches and mass media. Monitoring and evaluation of technology transfer process in term of technology adoption and impact on the productivity helped to reorient technology transfer strategies of the Institute for higher effectiveness. Effective technology transfer strategies has direct bearing on the productivity improvement of the coconut sector.

Technical Session - VIII

POSTER PRESENTATIONS

EFFECTS OF DIFFERENT HERBICIDE COMBINATIONS ON WEED CONTROL IN COCONUT NURSERIES IN THE DRY ZONE OF SRI LANKA

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The effect of four different weed management systems on the growth of coconut seedlings was evaluated to determine the most economical and effective method of controlling weeds in coconut nurseries in the low country dry zone of Sri Lanka. The treatments comprised; hand weeding (T_1), application of glyphosate at 1.44 kg ai/ha (continuous application) (T_2), application of glyphosate at 1.44 kg ai/ha (application before nut germination) + Diuron at 3.2kg ai/ha (application after seed nut germination) (T_3) and glyphosate at 1.44 kg ai/ha (application before nut germination) + oxyfluorfen at 270g ai/ha (application after seed nut germination) (T_4). All treatments were applied at three monthly intervals. According to the results, treatments T_2 and T_3 significantly reduced the weed biomass compared to those of other treatments. The growth of coconut seedlings (in terms of girth) increased significantly ($P < 0.05$) in treatment (T_3) at the end of nursery growth period. Treatment with glyphosate at 1.44 kg ai/ha (continuous application) (T_2) resulted in reduced growth of seedlings at the latter part of the experiment. The highest growth rate of coconut seedlings (girth) was observed in T_3 plots. According to the results the most effective and economically viable herbicide combination was the application of glyphosate at 1.44 kg ai/ha (before nut germination) + Diuron at 3.2kg ai/ha (after seed nut germination) (T_3) for controlling weeds in coconut nurseries.

EFFECT OF HOUSEHOLD EXTRACTION METHODS ON COMPOSITION AND FATTY ACIDS PROFILE OF COCONUT MILK

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Coconut milk, which is prepared traditionally in every household in Sri Lanka, varies in composition depending not only on the variety used but also on the amount of water added for the extraction as well as the method of preparation of coconut milk. Therefore an experiment was conducted with the objective of identifying different extraction methods used by households to extract coconut milk and to determine the effect of different extraction methods on the composition of coconut milk. A preliminary experiment was conducted in Kuliypitiya and Matara areas using 35 households as subjects. Different methods of coconut milk extraction and kernel: added water ratio were determined using an interviewer administered questionnaire and through direct observations while preparing meals. According to the results obtained in the preliminary survey, laboratory analysis was conducted at Coconut Research Institute, Lunuwila, Sri Lanka. Proximate composition of coconut milk extracted by different household extraction methods was analyzed using standard AOAC procedures and fatty acids profile was analyzed using fatty acid methyl esters in Gas Chromatograph. Data analysis was done by SAS Package using three-factor factorial design. According to the

results, majority of subjects were extracting coconut milk by hand squeezing. The other extraction methods identified were the blending followed by hand squeezing and grinding followed by hand squeezing. The extraction of fat into coconut milk was maximum (24.59% FWB) in blending followed by hand squeezing using hot water compared with both cold and hot water extraction of hand squeezing and grinding followed by hand squeezing. Hot water extraction gave significantly higher amount of fat than cold water extractions in all extraction methods. Grinding followed by hand squeezing using cold water resulted in significantly higher amount of proteins (2.21%) as well as short chain fatty acids in the first milk. Hand squeezing using cold water produced higher amount of lauric acid in both the first and second milk. The proximate composition and fatty acid profile of coconut milk extracted by different extraction methods were different in every level of extractions. Suitability of coconut milk as a nutritious food ingredient can be assessed through the method of its extraction as evident from the presented study.

VARIABILITY IN COCONUT GENOTYPES FOR FLORAL BIOLOGICAL TRAITS

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Knowledge of floral biology is important to understand adaptation and evolution of coconut. This work was taken up with the objective of analyzing the variability of floral biological traits in coconut germplasm. Seven tall accessions and three dwarf accessions were used in the study. Parameters such as duration of male phase, female phase, overlapping of male phase with female phases in the same inflorescence were recorded. Male phase in coconut varieties ranged from 20 to 23 days. It ranged from 19.5 to 24.5 days in case of hybrid coconuts. Female phase in tall varieties ranged from 3.5 to 5 days. In case of dwarf accessions it ranged from 7.5 to 10.5 days. Hybrid coconuts had a female phase of 1 to 8.5 days. Ratio of overlapping to female phase was worked out. Duration of female phase and overlapping to female phase are found to be important discriminating traits. They will serve as minimal descriptors in cataloguing germplasm. This study has practical implications in understanding reproductive biology of coconut accessions and hybrid varieties.

**DNA POLYMORPHISM AMONG COCONUT (*COCOS NUCIFERA* L.)
CULTIVARS AND RECIPROCAL CROSS DERIVATIVES
DIFFERING IN DROUGHT TOLERANCE**

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Coconut seedlings of Laccadive ordinary (LCT), Gangabondam dwarf (GBD) and their reciprocal cross combinations were analysed by molecular markers viz. Random Amplified Polymorphic DNA (RAPD) and Inter Simple Sequence Repeats (ISSR). These seedlings were evaluated for water stress tolerance based on leaf water potential measured during stress and non-stress periods. The leaf water potential decreased during stress period. The differences among the individuals for the leaf water potential during stress were not significant. The molecular markers revealed the genetic structure of the cultivars and derivatives clearly. In the dendrogram individuals of GBD and GBD x LCT formed one cluster and LCT and LCT x GBD formed another cluster. The individuals of LCT and LCT x GBD showed variation among themselves and they were scattered in the principal co ordinate plot. Even though the parents are same, the reciprocal cross derivatives behaved differently for the leaf water potential and showed polymorphism at DNA level. When the dwarf palm was used as female parent the F₁s are similar to female parent for the banding pattern.

**EFFECT OF SODIUM METABISULPHITE AND HEAT TREATMENT
ON ETHANOL PRODUCTION AND KEEPING QUALITY OF
BOTTLED TODDY**

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The sap (sweet toddy) obtained from the coconut inflorescence was treated with 0, 50,100 and150 ppm sodium metabisulphite(SMS) under laboratory conditions and the alcohol and acidity contents were measured for 10 days to identify the highest alcohol percentage and the lowest acidity content and the day on which they were formed. The highest alcohol percentage of 8.5 ± 0.2 % (v/v) and the lowest acidity content of 0.63 ± 0.04 % were reported for sap treated with 150 ppm sodium metabisulphite on the fifth day of fermentation under laboratory conditions. To keep this optimum alcohol content in a constant stage by preventing further fermentation and changes in the sap, heat sterilization was found to be the most satisfactory method. It was found that the toddy samples pasteurized either at 70 °C for 30 minutes or at 80 °C for 20 minutes, with 150 ppm sodium metabisulphite stored at room temperature gave satisfactory results, of alcohol contents as 8.1 ± 0.2 % and 8.0 ± 0.2 % respectively on six months of storage. The results of sensory evaluation revealed that more than 75 % of panelists preferred the taste and odour of products pasteurized either at 70 °C for 30 minutes or at 80 °C for 20 minutes and stored for six months at room temperature. Use of both sodium metabisulphite and heat preservation enhanced the quantity of ethanol and improved the quality of the final product for a shelf life of six months at room temperature.

**BIOCHEMICAL AND HISTOLOGICAL ANALYSIS OF IMMATURE
INFLORESCENCE TISSUES OF COCONUT (*COCOS NUCIFERA* L.)
TO SUPPORT *IN VITRO* CLONAL PROPAGATION**

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Clonal propagation of superior palms remains a promising possibility for the production of homogenous planting material for coconut plantations. Tissue culture is the only means of clonal propagation for coconut. Immature inflorescence material is a suitable source of explants for coconut tissue culture. However, a reliable protocol for regenerating plants from these explants is yet to be developed. Selection of inflorescence tissues at the correct developmental stage is vital for successful *in vitro* culture. The criterion used at present to select explants for *in vitro* culture is the length of inflorescence and explants are collected from inflorescences about 10 cm length. However, better selection criteria are needed to get consistent results. Thus accumulation of proline, starch and total sugar in a series of inflorescences of different maturity was assessed and histological analysis of these tissues were also undertaken with the aim of determining a possible correlation between these characteristics and morphogenic potential of inflorescence tissues. Samples for analysis were collected from unopened inflorescence tissues of -1 to -13 stages (considering the youngest open inflorescence as 0 stage), in decreasing order of maturity (i.e. -1 stage is the most mature stage whereas -13 is the most immature stage). A significant variation in the levels of proline, starch and total sugar was observed in inflorescence

tissues at different stages of maturity. A significantly higher level of total sugars was observed in -7, -8 and -9 stages when compared to other stages. With regard to proline content, no significant variation was observed in the stages from -4 to -11. The starch content was found to be relatively high in -8 to -13 stages and a declining trend was observed thereafter. The -8 stage in this study appears to correspond best to the 10 cm length inflorescence presently found most suitable for callus induction. A significantly higher level of total sugars was observed in -7, -8 and -9 stages than in the other stages. The higher accumulation of total sugars in -7 to -9 stages may have some significance in morphogenesis, especially as an energy source. The 10 cm length inflorescence that responds best for callusing falls within this range. Histological analysis also revealed that inflorescence tissues of -7 to -9 stages contain cells with high meristematic activity. Thus the high total sugar content and the presence of meristematically active cells in the -7 to -9 stages probably indicate the high morphogenic potential of these explants.

**ASSESSMENT OF KNOWLEDGE LEVEL AND FACTORS
AFFECTING ADOPTION OF RED WEEVIL CONTROL MEASURES
OF THE SMALL HOLDING SECTOR IN KULIYAPITIYA REGION**

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Red Weevil is the most serious and destructive pest of coconut, which affects the productivity of the coconut cultivation sector. Coconut Research Institute has made various recommendations to control the Red Weevil damage, but the level of adoption by the growers and their knowledge has not been assessed at the field level. A survey carried out in Kuliypitiya region during early 2004, revealed that, the age category of 5-10 years was the most susceptible to Red Weevil damage and the rate of damage in this group was 66%. The growers whose main income is not from the coconut cultivation, were reluctant to pay due attention to control Red Weevil. About 35% of growers were not aware to identify the Red Weevil or its development stages. The pheromone trap is aware by 40% and it is practiced by only 15%. A significant gap between the knowledge level and percentage of adoption was found for other recommended methods as well. Most of the growers have difficulties to purchase Monocrotophos at right time. The rate of adoption of control measures is significantly influenced ($P < 0.05$) by the knowledge of growers and extension contacts. Conducting awareness programmes, highlighting the monetary returns from Red Weevil control, regular field visits and implementation of different incentive programmes are suggested to increase the adoption.

**ASSESSMENT OF THE PRESENT SITUATION AND CONSTRAINTS
OF THE COCONUT SMALL HOLDERS IN KULIYAPITIYA REGION**

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Coconut small holder sector (< 4ha) has been not given due attention for several decades, though their contribution to the national coconut production is significant. A survey was conducted to assess the situation of the coconut small holder sector in respect of cultivation and management constraints in Kuliypitiya region. The survey found that the planting density of 55% of holders is below the recommended density. About 75% of the palms are under uneconomic age group (> 50 years) and 35% palms are senile palms (> 70 years). High percentage (62%) of the small holders uses local planting materials. The rate of application of fertilizer (irrespective of amount and frequency) is 65%, but 96% of them is not aware the correct method of application. The percentages of mulching with coconut fronds for young and mature palms are 70 and 55 respectively. The practice of husk burial or covercros is below 10% irrespective of age of palms. Red weevil (82.5%) and black beetle (72.5%) are the major pests among growers and the percentage of tapering palms and leaf scorch decline palms were 50% and 35% respectively. Practicing of irrigation for young and mature palms are 35% and 10% respectively. 62% of the small holders obtained advisory services from the Coconut Development Officers, but among them 60% was unsatisfied with present extension setup. High fertilizer cost, lack of timely and proper

advisory services, lack of planting materials, "Red tapes" in subsidy schemes etc. are main constraints faced by the growers. The results obtained are useful to improve the technology transfer methods to small holders and it is recommended to conduct such surveys to other areas on regular basis.