

# ANNOTATED BIBLIOGRAPHY OF COCONUT IN INDIA 1977-1990

COMPILED BY

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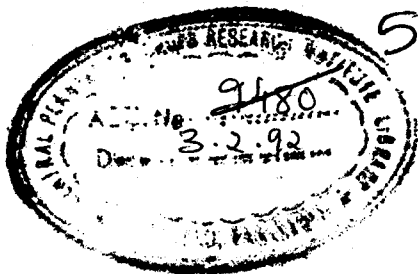
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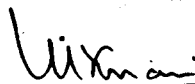
## FOREWORD

Behind the success of any research and development programme, a well-knit information input to researcher is a basic necessity. Due to the proliferation of knowledge in each and every subject area, no scientist can ever simultaneously get himself conversant with the latest developments in his subject area, and also pursue his research work. Under such a situation, the dire need for a specialised information service need not be overemphasized. This Institute is no exception to this and in fact, it is one of the mandates of the Institute to collect, collate and disseminate relevant information on specific areas of research at national level. As part of the information service programme of the Institute, a series of annotated bibliographies on arecanut, cashew, cardamom and coconut have already been published in the past.

On the occasion when the Institute is celebrating its Platinum Jubilee, it is quite appropriate to bring out a bibliography of all the Indian contributions to coconut research and development, for the benefit of the research workers. Already two bibliographies on 'Coconut in India' have been published covering literature upto 1976. This annotated bibliography includes 1291 references covering the period from 1977-1990. The coverage has been limited to Indian literature, as other major coconut growing countries viz., Philippines, Sri Lanka, Ivory Coast etc. have brought out a series of bibliographies at the international level.

The collection and compilation work for this publication has been done by Shri. D. Kamalavijayan and Shri. M.P. Ramesh Kumar. The editing of the manuscript was done by Shri. D. Kamalavijayan, Drs. C.P. Radhakrishnan Nair, B. Chempakam, M.P. Govindan Kutty and P.K. Das. Proofs were seen by Drs. S. Keshava Bhat, M.R. Hegde, Shri K. Vijayakumar and Dr. A.R.S. Menon.

I am sure that this bibliography will bring to light the enormous research and development work done on this important oilseed crop and will help the researchers and students to augment further research.



M. K. Nair  
Director

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Kasaragod  
14.11.1991

## COMPILERS' NOTE

This compilation covers the literature on coconut published in English from 1977 to 1990. In some cases (wherever it was possible) the papers published in January 1991 have also been included. Only published material on coconut research and development in India has been included in the bibliography.

In compiling this publication, the primary and secondary journals (numbering 490) subscribed at the Institute including CABI abstracting journals, Agrindex, Abstracts on Tropical Agriculture, Indian Science Abstracts etc. and other publications viz. books, technical reports etc. except that of annual reports, newspaper articles etc. available in the Library and Information Centre of the Institute were scanned. In addition to this, the coconut research and development workers and institutions in India viz. Coconut Development Board, Agricultural Universities of Kerala, Tamil Nadu, Karnataka, Gujarat, Andhra Pradesh, West Bengal etc., Universities of Calicut and Kerala, Regional Research Laboratory, Trivandrum etc. were contacted individually and literature collected so as to make this publication a most comprehensive one. The entry formats followed in this bibliography are based on the Chicago Style Manual (1989) with minor modifications. To facilitate the research workers in coconut for establishing more personal contact amongst themselves in their areas of work, the address of the first author of each reference has also been given along with almost all of the references. This will also help to ascertain the nature of work being carried out by the research and development agencies in the country on coconut. The annotations are generally based on author's abstract or summary. In certain cases abstracts have been prepared specially for this bibliography.

Entries have been grouped under 15 broad subject sections, viz. agricultural economics and marketing; agricultural statistics; agronomy; diseases: root (wilt) disease and other diseases; genetics, cytogenetics and plant breeding; horticulture and biotechnology; information service; microbiology: bacteria and fungi and mycorrhiza; mixed cropping; pests: insects, nematodes, mites and other arthropods and vertebrates; physiology and biochemistry; post harvest technology: building materials, coconut oil, coconut pith, coir, copra, energy, food and processing methods and devices; transfer of technology and general. Within each subject group, entries are arranged in alphabetical and chronological order of authors. Full titles of journals are given in abbreviated form and a list of acronyms and abbreviations used has been included in the preliminary pages. A detailed subject index and author index have also been appended.

We take this opportunity to thank our Director Dr. M.K. Nair for the encouragement and sincere support extended in bringing out this publication. We express our appreciation and thanks to Dr. C. P. Radhakrishnan Nair, Dr. (Mrs.) B. Chempakam, Dr. M.P. Govindankutty and Dr. P. K. Das for editorial work. We also thank Dr. S. Keshava Bhat, Dr. M. R. Hegde, Mr. K. Vijaya Kumar and Dr. A. R. S. Menon for proof correction. We are also grateful to our colleagues Sri. M. Divakaran Pillai, Smt. Sushama Devi and Smt. K. Shobha for their assistance rendered in the compilation of this bibliography. Ms. Ramoola Pereira, S/Sri K Venkatesh, K Ramadas and Ms. Leela deserve our appreciation for typing the manuscript neatly.

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## Journal Abbreviations Used

ALIS Bull.	Academy of Library and Information Science Bulletin.
Agric. Met.	Agricultural Meteorology
Agric. Res. J. Kerala	Agricultural Research Journal of Kerala
Agric. Situ. India	Agricultural Situation in India
Agric. Wastes	Agricultural Wastes
Agric. & Agro Ind. J.	Agriculture and Agro Industries Journal
Agric. Forest Meteorol.	Agriculture and Forest Meteorology
Andhra Agric. J.	Andhra Agriculture Journal
Ann. Bot.	Annals of Botany
Ann. Entomol. Soc. Amer.	Annals of the Entomological Society of America
Appropriate Technol.	Appropriate Technology
Bull. Entomol. Res.	Bulletin of Entomological Research
Bull. Entomol.	Bulletin of Entomology
Ceylon Cocon. Q.	Ceylon Coconut Quarterly
Chem. Abstr.	Chemical Abstracts
Cocon. Bull.	Coconut Bulletin
Coir Quart. J.	Coir Quarterly Journal
Curr. Res.	Current Research
Curr. Sci.	Current Science
Environ. Ecol.	Environmental Ecology
FAO Plant Prot. Bull.	FAO Plant Protection Bulletin
Far. Parliament	Farmer and Parliament
Fmg Agric.	Farming Agriculture
Fertilizer Res.	Fertilizer Research
Fibre Sci. Technol.	Fibre Science Technology

Food Chem.	Food Chemistry
Food Fmg Agric.	Food Farming and Agriculture
Gujarat Agric. Univ. Res. J.	Gujarat Agricultural University Research Journal
Hort.	Horticulture
Indian Agric.	Indian Agriculture
Indian Cocoa, Arecanut, Spices J.	Indian Cocoa, Arecanut and Spices Journal
Indian Cocon. J.	Indian Coconut Journal
Indian Fmrs Dig.	Indian Farmers Digest
Indian Fmg	Indian Farming
Indian J. agric. Sci.	Indian Journal of Agricultural Science
Indian J. agric. Econ.	Indian Journal of Agricultural Economics
Indian J. Ent.	Indian Journal of Entomology
Indian J. Exptl Biol.	Indian Journal of Experimental Biology
Indian J. For.	Indian Journal of Forestry
Indian J. Med. Res.	<i>Indian Journal of Medical Research</i>
Indian J. Microbiol.	Indian Journal of Microbiology
Indian J. Mycol. Pl. Path.	Indian Journal of Mycology and Plant Pathology
Indian J. Nematol.	Indian Journal of Nematology
Indian J. Nutr. and Dietetics	Indian Journal of Nutrition and Dietetics
Indian J. Pl. Pathol.	Indian Journal of Plant Pathology
Indian J. Pl. Physiol.	Indian Journal of Plant Physiology
Indian J. Plant Prot.	Indian Journal of Plant Protection
Indian J. Technol.	Indian Journal of Technology
Indian J. Virol.	Indian Journal of Virology
Indian Phytopathol.	Indian Phytopathology
Intensive Agric.	Intensive Agriculture
Inter. Biodeterioration	International Biodeterioration
JAOCS	Journal of American Oil Chemists Society

J. And. Sci. Assoc.	Journal of Andaman Science Association
J. Appl. Polym. Sci.	Journal of Applied Polymer Science
J. Biol. Control	Journal of Biological Control
J. Bombay Nat. Hist. Soc.	Journal of the Bombay Natural History Society
J. Chem. Tech. Biochem.	Journal of Chemical Technology and Biochemistry.
J. Entom. Res.	Journal of Entomological Research
J. Food Sci. Technol.	Journal of Food Science and Technology
J. Indian Bot. Soc.	Journal of Indian Botanical Society
J. Meter. Sci.	Journal of Meteorological Science
J. Mater. Sci. Lett.	Journal of Material Science Letters
J. Nat. Hist.	Journal of Natural History
J. Nuclear Agric. Biol.	Journal of Nuclear Agriculture and Biology
J. Plant. Physiol.	Journal of Plant Physiology
J. Plantn Crops	Journal of Plantation Crops
J. Res. Andhra Pradesh Agric. Univ.	Journal of Research, Andhra Pradesh Agricultural univerisity
Labdev. J. Sci. Technol. Part B. Life Sci.	Labdev Journal of Science and Technology Part B Life Science
J. Sci. Food Agric.	Journal of the Science of Food and Agriculture
J. Sci. Ind. Res.	Journal of Scientific and Industrial Research
J. Sci. Res.	Journal of Scientific Research
J. Swamy Bot. C.	Journal of Swamy Botanical Club
J. Indian Soc. Agric. Statist.	Journal of Indian Society of Agricultural Statistics
J. Indian Soc. Soil Sci.	Journal of the Indian Society of Soil Science
J. Trop. Sci.	Journal of Tropical Science
Kisan Wld	Kisan World
Madras Agric. J.	Madras Agricultural Journal

Mysore Agric. Sci. J.	Mysore Agricultural Science Journal
Mysore J. Agric. Sci.	Mysore Journal of Agricultural Science
Nematol. Medit.	Nematologia Mediterania
Orissa J. Hort.	Orissa Journal of Horticulture
Outlook on Agric.	Outlook on Agriculture
Philipp. J. Cocon. Studies	Philippine Journal of Coconut Studies
Pl. Soil	Plant and Soil
Plant Biochem. J.	Plant Biochemistry Journal
Pl. Dis.	Plant Disease
Pl. Dis. Reprtr	Plant Disease Reporter
Pl. Path. Newsletter	Plant Pathology Newsletter
Pl. Physiol. Biochem.	Plant Physiology and Biochemistry
Plant Prot. Bull. India	Plant Protection Bulletin of India
Plant Sci. Lett.	Plant Science Letters
Plr's Chron.	Planter's Chronicle
Potash Rev.	Potash Review
Proc. Indian Acad. Sci. (Ani. Sci.)	Proceedings of the Indian Academy of Sciences (Animal Science)
Proc. Indian Acad. Sci. (Plant. Sci.)	Proceedings of the Indian Academy of Sciences (Plant Science)
Proc. Indian Natl. Sc. Acad.	Proceedings of Indian National Science Academy.
Q. Bull. IAALD	Quarterly Bulletin of International Association of Agricultural Librarians and Documentalists.
Res. Industry	Research and Industry
Rural Technol. J.	Rural Technology Journal
Soil Biol. Bichem.	Soil Biology and Biochemistry
South Indian Hort.	South Indian Horticulture
Tex. Res. J.	Textile Research Journal

Trans. Br. Mycol. Soc.

Trans Indian Inst. Metals

Trop. Agric.

Trop. Ecology & Develop.

Wood Sci. Technol.

Wld Crops

Z. Pflanzenphysiol.

Transactions of the British Mycological  
Society.

Transactions of the Indian Institute of Metals

Tropical Agriculture

Tropical Ecology and Development

Wood Science Technology

World Crops

Zeitschrift Pflanzenphysiolgy

## Acronyms and Abbreviations Used

AICCAIP	All India Co-ordinated Coconut and Arecanut Improvement Project
AICRP	All India Co-ordinated Research Project
A & N Islands	Andaman and Nicobar Islands
A.P.	Andhra Pradesh
APAU	Andhra Pradesh Agricultural University
APCC	Asian and Pacific Coconut Community
ASEAN	Association of South East Asian Nations
Agric.	Agriculture
BARC	Bhabha Atomic Research Centre
BCKVV	Bidhan Chandra Krishi Visva Vidyalyaya
CARI	Central Agricultural Research Institute
CBRI	Central Bee Research Institute
CCRI	Central Coffee Research Institute
CFTRI	Central Food Technological Research Institute
CID/IDRC	Centre for Information and Documentation/ International Development Research Centre
CIFT	Central Institute of Fisheries Technology
COD	Chawaghat Orange Dwarf
COCOTECH	Coconut Technology
CPPTI	Central Plant Protection and Training Institute
CRIDA	Central Research Institute for Dryland Agriculture
CTCRI	Central Tuber Crops Research Institute
CWRDM	Centre for Water Resources Development and Management
DBCP	Dc Bromd Chloro Propane
DRIS	Diagnosis and Recommendation Integrated System
Dept.	Department

Div.	Division
ECT	East Coast Tall
GAU	Gujarat Agricultural University
GKVK	Gandhi Krishi Vignan Kendra
Hort.	Horticulture
IAEA	International Atomic Energy Agency
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICRAF	International Council for Research in Agroforestry
IIHR	Indian Institute of Horticultural Research
ISPP	Indian Society for Plant Physiology
JTRL	Jute Technological Research Laboratory
KAU	Kerala Agricultural University
KFRI	Kerala Forest Research Institute
LO	Laccadive Ordinary
MDY	Malayan Dwarf Yellow
NABARD	National Bank for Agriculture and Rural Development
NARP	National Agriculture Research Project
NIRD	National Institute of Rural Development
OUAT	Orissa University of Agriculture and Technology
Path.	Pathology
PLACROSYM	Plantation Crops Symposium
RARS	Regional Agricultural Research Station
RC	Research Centre
RCRS	Regional Coconut Research Station
Res.	Research
RRII	Rubber Research Institute of India
RRL	Regional Research Laboratory

RS	Regional Station
SABRAO	Society for the Advancement of Breeding Researches in Asia and Oceania
SADU	Special Agricultural Development Unit
T.N.	Tamil Nadu
TNAU	Tamil Nadu Agricultural University
UAS	University of Agricultural Sciences
UNIDO	United Nations Industrial Development Organization
UPASI	United Planter's Association of South India
Univ.	University
W.B.	West Bengal
WCT	West Coast Tall

# 1. AGRICULTURAL ECONOMICS & MARKETING

1. CHANDY, JOHN. 1985. Export of Indian coir; problems and prospects. *Coir* 29(2):8-10. (Coir Board, Alleppey, Kerala).

During second half of 1950's the average export of coir products in state was 14,676 tonnes valued at Rs. 22.76 million. The export increased continuously both on quantity and value during subsequent years touching a maximum of 17,631 tonnes valued at Rs. 45.21 million during second half of 1970's. Thereafter the average export of coir product from India declined and reached 13,137 tonnes during the first 5 years of 1980's, valued at Rs. 154.22 million. The export of coir product to Europe, U.S.A., Canada, Australia and U.S.S.R. have declined in 1980-81. One major factor effecting growth of coir products relates severe competition from rubber, plastics and other synthetic items which have higher consumer approach.

2. CHATTERJEE, R.K. and GHOSE, SUGATHA. 1990. A study of tender nut market of Calcutta. *Indian Cocon. J.* 21(7-8): 18-21. (Coconut Development Board State Centre, Calcutta, W.B.)

Tender coconut is a very popular natural drink of the Calcuttans, especially of its six lakh strong floating population. The entire demand of the Calcutta market is met by the four surrounding districts of 24 - Parganas (North), 24 - Parganas (South), Howrah and Hoogly. In between the farmers and the consumers, the market network involves village agents, weekly collection centres, wholesale fruit markets of Calcutta and roadside vendors. Farmers prefer harvesting tender nuts because of higher productivity, heavy demand and ready market in Calcutta. It also brings frequent cash return, avoids theft threats and reduces loss caused

by pests and diseases. Comparative economics of harvesting tender and mature nuts, when equated at yearly basis, shows that the gross return from harvest of tender nuts comes to Rs. 92.00 per palm whereas from mature nuts it is only Rs. 80.00 per palm. Though tender nut harvesting is not so common in India, in this study it was found that the venture is profitable for the coconut growers of West Bengal.

3. COCONUT DEVELOPMENT BOARD, COCHIN. 1986. Market research studies on coconut products. *Indian Cocon. J.* 17(7):3-31.

This paper highlights the findings of the survey conducted by the Coconut Development Board during the period 1984-85. The subject includes (i) harvesting practices and harvesting charges; (ii) pattern of disposal of coconuts by farmers; (iii) trade allowance and (iv) copra.

4. DAS, K.K.; DAS, M.M. and DAS, R.K. 1980. Measuring potentiality of communication media for popularising coconut oil in rural India. *Indian Cocon. J.* 11(3):3-4. (IARI, New Delhi, 110012).

A survey was carried out in randomly selected 18 states in India to find out the potentiality of different communication media for popularizing coconut oil.

5. DAS, P.K. 1983. Coconut situation in India. *Agric Situ. India* 38(3): 275-282. (CPCRI, Kasaragod, Kerala).

Growth rates on area, production and yield of coconut in different five year plan periods during the time span 1951-1981 are shown in respect of different coconut growing areas. The area under coconuts in India increased from 625,500 ha in 1950-51 to 1074,400 ha in 1980-81. Similarly, the production of nuts rose from 3282 million nuts to 5753 million

nuts during that period. The compound growth rates of the area and production per year between 1950-51 and 1980-81 were 2.40% and 1.56% respectively.

6. DAS, P.K. 1984. Estimating production costs and returns for coconut in Kerala. *J. Plantn Crops* 12(2):152-159. (CPCRI, Kasaragod, Kerala).

The cost of production of coconuts in Kerala has been estimated at Rs. 1.10/nut under 1982-83 factor costs, but without taking the value of land into consideration. When a moderate price of Rs. 50,000 per hectare of land is added to the investment on coconuts, the production cost goes upto Rs. 1.94/nut. In view of the fact that the rate of appreciation of land is significantly higher than that of bank rates and the land market is out of normal economic ambit, there is no justification to include land value in the investment in present Kerala situation.

Considering the average production cost and farmgate price of coconut as Rs. 1.10 and Rs. 1.50/nut respectively, the net return works out to be Rs. 4200/ha. Further, since coconut is a smallholder plantation crop at least 75 percent of labour required for various operation excluding harvesting could be expected from the farmer's family itself. Therefore the returns to family labour and investment per hectare of coconut garden comes to Rs. 5760/annum. The study thus reveals that coconut cultivation under good management is a profitable proposition in Kerala.

7. DAS, P.K. 1984. The place of coconut oil in Indian vegetable oils. *Agric. Situ. India* 39(5): 317-324. (CPCRI, Kasaragod, Kerala).

Coconut oil occupies third place in Indian vegetable oil sector next only to groundnut oil and rapeseed-mustard oil, but its total production is about one-seventh of the production of groundnut oil and two-fifth of the

production of rapeseed-mustard oil. It constitutes nearly 6-7% of the total vegetable oil production in India.

The net available supplies (in tonnes) of coconut oil in India rose from some 1,26,000 (1,20,000 production and 6,000 imports) in the year 1947-48 to 2,60,000 (1,97,000 production and 63,000 imports) in the year 1960-61. From 1961-62 while the production of coconut oil in the country remained more or less steady around 1,80,000 the imports of coconut oil had been on a much reduced scale upto 1976-77 with the result that the supplies of this oil have declined to an appreciable level.

8. DAS, P.K. 1984. Possibilities of increasing productivity of coconuts from non-monetary inputs. *J. Indian Soc. Agric. Statist.* 37(2):102-103. (CPCRI, Kasaragod, Kerala).

Considerable scope exists for increasing the productivity of coconuts in India by adopting proper spacing and correct method of planting; transplanting healthy and hybrid seedlings; following regular cultural practices; application of agricultural wastes; providing micro-irrigation and adopting phytosanitary measures.

9. DAS, P.K. 1984. Trends in coconut oil production and trade in the world. *Oleagineux* 40(2): 85-93. (CPCRI, Kasaragod, Kerala).

A review of the trends in coconut oil production and trade against the background of the trends in the world coconut area and production has been made for the period 1966 to 1980. The annual compound growth rates of area, production and yield rate for this period are estimated at 3.58%, 2.14% and (-) 0.96%, respectively. Coconut palms occupied an area of about 8.26 million ha and produced nearly 35 million tonnes of nuts, per year with an average productivity of 4.5 per ha during 1976-80. The growth rates in respect of copra and coconut oil productions come near 2.4% in

both the cases, while the same for the exports of copra and coconut oil in terms of oil works out as 2.1% over a period of one and half decades ending 1980. During 1976-80 the average volumes of copra and coconut productions stood at 4.64 million t and 2.84 million t/year. The USA, West Germany, Netherlands, France and Japan are the major importers of coconut oil. Rapid growth in the production of soya oil and palm oil and their availability at competitive prices are the main causes for the decline in the pre-eminent trade position of coconut oil in the world.

10. DAS, P.K. 1985. Cost of production and cost benefit analysis of smallholder plantation crops under ideal management. Kasaragod: CPCRI. Technical Bulletin no. 12. 13p. (CPCRI, Kasaragod, Kerala).

The cost of production of West Coast Tall (WCT) coconuts raised under rainfed condition of Kerala was estimated as Rs. 1.05 per nut. When the same WCT coconuts are raised under irrigated conditions the cost of production gets reduced to Rs. 0.90 per nut because of the higher productivity. In the case of hybrid coconuts raised under irrigation the cost of production further reduces to Rs. 0.60 per nut due to their higher energy conversion efficiency than that of the WCT. The BCR in respect of rainfed WCT coconuts, irrigated WCT coconut and irrigated hybrid coconut production were assessed as Rs. 1.30; 1.75 and 2.08 respectively. Similarly the Internal Rate of Return (IRR) values were 18, 22 and 25%.

11. DAS, P.K. 1985. Trends in oilseed production and utilization in India. In Oilseed production; constraints and opportunities. New Delhi: Oxford and IBH. p. 275-285. (CPCRI, Kasaragod, Kerala).

The perennial oil-yielding coconut palms of India constituted 14% of world coconut area while the production of coconuts accounted for 13%. India occupied second place with

an average yield of 3.96 t nuts/ha, next only to Indonesia (5.96t). However, the world average yield is 4.15 t/ha. It is observed that the present dismal situation arising out of extremely low productivities could be changed by the adoption of new technologies in coconut farming at least by 200% over the existing national average of 30 nuts per palm per annum.

12. DAS, P.K. 1986. Marketing of coconuts in India; state of the art. *Coconuts Today* 3(2):48-53. (CPCRI, Kasaragod, Kerala).

Coconut is not only an important oil yielding tree crop but also a favourite in India. The utilization of four to eight month old tender nuts as a refreshing drink is in the order of some 200 million nuts per annum. The remaining 6000 million nuts are used in several forms, both edible and inedible. The major portion of marketed surplus is sold in the villages. In Kerala, for example, the sales in the village to the middlemen account for 81% of the total disposal and the direct sales by the growers in cooperatives and assembling markets constitute 1.5% and 17.5% respectively.

13. DAS, P.K. 1986. Movement of wholesale prices of coconuts, copra and coconut oil in Kerala during the last two and a half decades. *J. Plantn Crops* 14(2):105-114. (CPCRI, Kasaragod, Kerala).

This study reveals the highly erratic nature of movement of wholesale prices for coconuts, copra and coconut oil in respect of Calicut market which reflects the situation of entire Kerala State. Coconut prices per 1000 nuts for example, increased from Rs. 186 in 1960-61 to Rs. 577 in 1970-71 with year to year fluctuations. In 1971-72 it came down to Rs. 416, again moved upward and in 1974-75 it stood at Rs. 864, but crashed to Rs. 654 in the following year. In the year 1984-85 the price was an all time record of Rs. 2602 while in the following year it was as low as Rs. 1251.

Small holder Smallholder Cost of production

Oil seed production

Price

The violent fluctuations in these prices are found to be far more than one reason. The major factor behind this is the uncertainty of weather which leads to the volatility in the supply demand gap in the edible oil sector in general and coconut oil sector in particular. While the prospects of improved supplies of oilseeds and anti-inflationary measures favour the lowering of prices, the unfavourable weather, restricted imports, higher tariff values, inflationary spiral, and black economy push the prices forward. Easy availability of comparatively cheaper substitutes to coconut oil both in the edible and inedible sectors appears to have made coconut oil noncompetitive, thus vulnerable to crash in prices in favourable years of production. For evading the present crisis of slump in coconut sector it is suggested to develop technology on the alternative use of the coconuts; to extend the support price or market intervention price system to milling copra and to adopt scientific coconut farming system which ultimately bring desired cost effectiveness in coconut through increased productivity.

14. DAS, P.K. 1987. Coconut marketing problems, prospects and challenges. *In: National Seminar on Coconut Marketing and Processing, Bangalore, Apr. 19-20, 1987. Proceedings of seminar. Edited by P.K. Thampan and others. Cochin: Coconut Development Board. p. 134-141. (CPCRI, Kasaragod, Kerala).*

It is estimated that about 81% of marketed surplus of nuts in Kerala are sold to the middlemen by the farmers at their farmgates. Pre-harvest contract and inaccessibility to market give rooms for sales at gardens under these situations, the middlemen abuse their positions by resorting to various types of malpractices. This paper attempts to identify the specific problems in coconut marketing and processing sectors; find out various issues in connection with those problems; and suggest appropriate measures for solving those problems. One of

the important suggestions is to promote group action based on spatial and functional considerations.

15. DAS, P.K. 1987. Economics of cocoa mixed-cropping with coconuts in India. *In: Symposium on Plantation Crops, 6th, RR11, Kottayam, Dec. 16-20, 1984. Proceedings of PLACROSYM VI. Edited by M.R. Sethuraj and others. p. 397-408. (CPCRI, Kasaragod, Kerala).*

→ This study aims to find out whether cocoa could be a compatible as well as profitable intercrop with coconuts. The analysis reveals that the net return from cocoa grown in the interspaces of coconuts amounts to Rs. 2900/ha/year. The coconut-cocoa system as a whole promises a net return of Rs. 16,500/ha/year as against Rs. 7300/ha/year in the case of rainfed coconut monoculture. In view of this, the interplanting of cocoa with coconuts is found to be promising.

16. DAS, P.K. 1988. Economics of coconut-based farming systems. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Thrichur, Nov. 23-28, 1988. Abstracts of papers. p. 42-43. (CPCRI, Kasaragod, Kerala).*

→ Feasibility studies under rainfed situation involving different species and varieties of cereals, pulses, oilseeds, tubers and rhizomatous crops are relatively more compatible and remunerative intercrops than that of other annuals in coconut gardens of Kerala. In the case of multistoreid cropping under irrigation the benefit-cost ratio (BCR) in this system comes to 1.76, the internal rate of return (IRR) is higher than 20% and the annual Net Present Worth (NPW) is Rs. 32,700.

While the annual employment generation in 1 ha rainfed coconut monocrop and irrigated coconut monocrop were assessed at 120 and 144 mandays, the same was estimated at 320 mandays in the case of rainfed coconut+ginger system, 335 mandays on coconut+pepper+

coconut+pineapple mixed cropping system and 850 mandays in coconut based milch cow integrated mixed farming system.

17. DAS, P.K. 1989. Economics of coconut based farming systems. *Cocomunity*, APCC/QS/ 19:1-12. (CPCRI, Kasaragod, Kerala).

The economic prospects of different coconut based farming systems in Kerala conditions were compared in terms of net profit per hectare per annum based on the 1988 market situations. Elephant-foot-yam and ginger were more compatible and remunerative intercrops under rainfed conditions. The net returns from these were Rs. 18,550 and Rs. 14,350 per hectare respectively. For an irrigated coconut garden of 25 or more years old, coconut+black pepper+cocoa+pineapple system has given the highest net return (Rs. 33,550/ha/year). The net returns from a mixed farming system (coconut+black pepper+ banana + vegetable+hybrid napier+5 units of crossbred cows+30 units of rabbits) was Rs. 29,500/ha/year, but on adding the return from family labour, the total return of family was Rs. 50,000/ha/year. The employment generation was also maximum in this system.

18. DAS, P.K. 1989. Relevance of coconut based cropping systems. In: Workshop on Agro-economic Aspects of Extension Methodology for Intercropping in Coconut, APCC/CPCRI, Mar. 27-Apr. 7, 1989. Proceedings of workshop. p. 1-6. (CPCRI, Kasaragod, Kerala).

Present state of the art of coconut based homestead farming suggest that the technical feasibilities of these systems are grossly misused, thus the opportunities to maximize the economic gains per unit area, input and time are lost. In order to derive the maximum returns from the systems, first the homestead gardens need to be restructured with proper spacing. Next, the component technologies are required to be developed through location specific field trials. It was also felt that much could be

achieved by improving institutional credit supply position and guaranteeing remunerative prices for component crops. The advantages of scientifically laid out coconut based mixed farming systems over haphazardly raised homestead gardens are discussed.

19. DAS, P.K. 1989. Relevance of mixed cropping systems. *Cocomunity*, APCC/QS/ 20:46-54. (CPCRI, Kasaragod, Kerala).

It has been observed that in the coconut based and other tree based mixed cropping trials the fertilizer response of the individual plant species changes to a considerable extent because of the species interaction, thus effecting the economy in energy use. Again, the water requirement of one crop or a number of crops growing simultaneously in a given area will remain nearly constant; thus polyculture is more beneficial from water use efficiency point. Mixed cropping provides good soil cover and suppress weed growth through plant-weed competition. The system therefore effect good saving in the cost of weed control. The tree based cropping systems like multistoreyed cropping in coconuts are counter-seasonal and growing assets like savings bank deposits which can be used to meet contingencies.

20. DAS, P.K. 1989. State of the art of copra production and marketing in India. *Coconuts Today* 4:34-41. (CPCRI, Kasaragod, Kerala).

It is estimated that some 60% of 6887 million nuts produced in India in a year is directly used in a variety of culinary forms in the household sector. The remaining 40% of mature nuts, except 10 million seednuts, is primarily processed into coconut products. (3,45,000 tonnes of milling copra; 45,000 tonnes of edible copra; and a small 4000 tonnes of desiccated coconuts).

In Kerala about 15% of milling copra is made by the coconut growers themselves and the remaining is processed by some 5000

Farming systems

Mixed cropping

Mixed cropping

professional copra makers. In India, because of the small size of nuts on an average 6800 coconuts give 1 tonne of copra against 4500 nuts in the Philippines and Indonesia.

21. DAS, P.K. 1990. Economics of coconut based farming systems. *In: COCOTECH Meeting on Coconut Based Farming Systems, 27th, Manila, Philippines, Jun. 25-29, 1990. Proceedings of the meeting. p. 539-554. (CPCRI, Kasaragod, Kerala).*

Economic analysis of rainfed systems suggested that while the return to investment from 1 ha coconut monocrop was 13.1%, it was 28.5% in case of coconut + cassava system, 47.6% in coconut + elephant-foot-yam system and 25.6% in coconut + ginger system.

Among several feasible combinations under irrigated coconut gardens, one of the most successful systems was the integration of black pepper, pineapple and cocoa with adult coconut palms of over 20 years age. This multistoreyed system generated a net return of US \$ 19,895/ha/year, as against US \$ 1450 in the case of irrigated coconut monocrop raised under similar situation. Return to investment rose from 43.0% in the case of coconut monocrop to 65.1% in multistoreyed cropping model.

These systems smoothed out the peaks and valleys of labour demand which could be considered a positive aspect for the smallholder.

22. DAS, P.K. 1990. Price instability in coconut products in Kerala during eighties. *In: Symposium on Plantation Crops, 9th, CCRI, Chikmagalur, Dec. 5-7 1990. Abstracts of papers. p. 89-90. (CPCRI, Kasaragod, Kerala).*

In this study the major causes of price instability in coconut products namely nuts, copra and coconut oil have been identified. This study further indicates that compared to the prices of essential commodities like rice,

pulses, sugar and tea, coconut prices have not shown any appreciable increase in the last five years.

23. DAS, P.K. 1990. Rural women: their role and status in coir and cashew processing sectors of Kerala. *In: National Seminar on Rural Women and Agriculture, NIRD, Hyderabad, Jan. 29-31, 1990. Proceedings of seminar. p. 22-32. (CPCRI, Kasaragod, Kerala).*

The coir and cashew processing sectors are by far the largest employers of rural women in Kerala. In coir sector, women are assigned the most difficult task of defibering and cleaning of retted husks. The extraction of husk is mainly done by hand. Eventhough the task is difficult, the earnings are very low when compared with the remuneration for other works. However, when the defibering operation is done by machines, women are conveniently pushed out by men for some other marginal jobs.

24. DAS, P.K. 1990. State of art of coconut oil production and utilization in India. *Coconuts Today* 5:70-73. (CPCRI, Kasaragod, Kerala).

Coconut oil production in India fluctuated between 170,000 tonnes and 200,000 tonnes during 1960-'61 to 1979-'80. In the eighties it ranged between 210,000 tonnes and 240,000 tonnes. It may be remembered that only about one-third of coconuts produced in India is diverted towards the production of oil and the remaining portion is consumed in nonoil forms. The current level of coconut production in India which is around 6800 million nuts could yield some 600,000 tonnes of oil if the entire production is processed into oil.

25. DAS, P.K. 1991. Price behaviour of coconut oil in relation to major oils in India. *J. Plantrn Crops* 18(Suppl.):376-382. (CPCRI, Kasaragod, Kerala).

Studies conducted on the wholesale prices of four edible oils viz., coconut oil, groundnut

oil, sesame oil and mustard oil for the period 1970-'71 to 1987-'88 revealed that coconut oil had commanded a relatively higher price over other oils during most of the years. The compound growth rates worked out for these oil prices were almost of the same order (8 to 9.6%). But instability in prices were more for coconut oil than other oils. This study also revealed that the relative increase in prices of groundnut oil, sesame oil and mustard oil over the years was much higher than that of increase in coconut oil prices. Correlation studies revealed that the prices of these edible oils move very closely with each other with correlation coefficient between 0.88 to 0.90. Regression analysis showed that the wholesale prices of any oil could be predicted with high precision knowing the price of any other oil.

26. DAS, P.K. 1991. Price behaviour in India's coconut sector. *CORD* 7(1):1-9 (CPCRI, Kasaragod, Kerala).

Coconut being a smallholder perennial crop, studies on the price behavior of its products require serious consideration. A cursory look into the price structure of coconut, copra and coconut oil reveal that the price fluctuations are not only infrequent, but also most violent. The seasonal indices show different patterns for different products.

The Compound Growth Rates of wholesale prices for coconut products are found to be around 10 per cent per annum between 1970 and 1989. The indices however suggest that the relative prices in coconut sector are declining even though the absolute prices show significant growths. The correlation coefficients ( $r$ ) between wholesale prices of coconut products are assessed as 0.99. The analysis of price behaviour in the important coconut product markets further reveals that those markets are highly competitive.

Attempts have been made to predict the

prices of copra with the use of coconut oil prices; and the prices of coconut with the use of prices of either copra or coconut oil in the same market or in different markets. The prediction models are found out to give good fit with the value of  $r^2$  ranging between 0.98 and 0.99.

27. DAS, P.K. and VIJAYAKUMAR, K. 1991. Evaluation of LER and its advantages in coconut/arecanut based systems. *J. Plantn Crops* 18(Suppl.):356-358. (CPCRI, Kasaragod, Kerala).

Advantages in coconut and arecanut based mixed cropping systems are studied using Land Equivalent Ratio (LER), Monetary advantage (MA), Agressivity Index (A) and Competition Ratio (CR). Under rainfed system, coconut and ginger gave a monetary advantage of Rs. 20,683 per ha per year with a corresponding LER of 1.56. Coconut and turmeric recorded a monetary advantage of Rs. 16,483 per ha per year with LER of 1.41.

28. DAS, P.K.; VIJAYAKUMAR, K.; BALAKRISHNAN, P.; DAMODARAN, V.K.; REMA BAI, S. and AMARNATH, C.H. 1984. Trends in coconut area and production in India. In: *Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 12-15, 1991*. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p. 55-61. (CPCRI, Kasaragod, Kerala).

Between 1950-'51 and 1980-'81 though the area planted under coconut has been quite noticeable, the production growth rate has always lagged behind the planting rate, suggesting that productivity is declining. During the 1970s, the compound growth rate of coconut yield for Kerala was (-) 2.0%/year, while the corresponding rates for the other major producing states, namely Tamil Nadu and Karnataka were 1.0% and 0.17% respectively. The trend in all India productivity for the period under reference was (-)0.9%/

year. We should plan for a growth rate of 7.0% to bridge the supply gap.

29. **GHOSE, SUGATA.** 1990. Coconut situation in Manipur. *Indian Cocon. J.* 21(5):2-8. (Coconut Development Board State Centre, Guwahati 781 006, Assam).

Manipur is the eastern most state of India. Though coconut is traditionally used in the social, cultural and religious life in Manipur, the systematic plantation of coconut in this state is only of recent origin. The tropical agro-climatic condition limits the scope of large scale commercial cultivation of the crop all over Manipur.

30. **JOB, ELSAMMA and PRAKASH, R.** 1988. Economics of coconut cultivation; a study in Trivandrum district. *Indian Cocon. J.* 21(5):2-8. (College of Agric., KAU, Trivandrum-695 022, Kerala).

In this study, it was observed that the maintenance cost per hectare per year amounted to Rs. 6,976. The major operation in terms of cost was found to be manures and manuring. Labour accounted to about 38% of the cost of maintenance. Even though proper management and adoption of recommended technologies were lacking, net return per hectare was found to be Rs. 7,542. Since coconut is intercropped with perennial and seasonal crops, it makes coconut cultivation more profitable.

31. **JONES, STEPHEN F.** 1988. The market situation of desiccated coconut in Assam. *Indian Cocon. J.* 19(7):3-6. (Coconut Development Board State Centre, Guwahati, Assam).

In early eighties only about 36 t of desiccated coconuts was handled in Guwahati market annually to cater to the needs of the north-eastern region. In 1988, it has increased by almost five times (about 175 t) a year. The demand is increasing not only in the bakeries,

sweet shops but also in the household sector. However, the entire product comes from Karnataka and Tamil Nadu.

32. **JOSEPH, M.S. and DAS, P.K.** 1986. Marketing and price stabilization of coconut. In: Seminar on Production and Productivity of Coconuts in India, *Trivandrum, Ministry of Agriculture, Govt. of India, Sep. 27, 1986.* Proceedings of seminar. p. 43-53. (Dept. of Agric., Govt. of Kerala, Trivandrum, Kerala).

The marketing of coconuts in India is done in three ways viz., mature nuts, copra and tender nuts. The per capita consumption of coconut varies widely with an average of 27.5 nuts/year in Kerala region. Nearly 10 million nuts a year are used for raising seedlings. The method of disposal of nuts varies from region to region. A large proportion of the farmers dispose of their produce to middlemen. From them it reaches to the wholesale merchants and commission agents and they, in turn despatch to the consuming centres. It is estimated that about 2500 million nuts get converted into copra every year in India. The major clients for copra are the oil mills and consumers from upcountry markets. Out of the 3.5 million tonnes of yearwise production of milling copra, Kerala contributes as high as 96%. However Karnataka followed by Andhra Pradesh meet the demand for ball copra. The prices of coconut, copra and coconut oil are highly unstable in the country. To make the crop remunerative, several suggestions have been made.

33. **MATHEW, JACOB.** 1980. Interdistrict variation in the prices of coconuts, copra and coconut oil in Kerala. In: Symposium on Plantation Crops, 3rd, CIFT, Cochin, Dec. 12-15, 1980. Proceedings of PLACROSYM III. Edited by K.V. George and others. p. 362-373. (CPCRI, Kasaragod, Kerala).

The variations in the wholesale prices

of coconuts, copra and coconut oil in Kerala from 1958 onwards were studied. While the inter-district variations in the price of copra and coconut oil remained more or less steady over the years, the variations in the prices of coconuts was found to increase with prices. The possible reason for this phenomena are discussed.

34. MATHEW, JACOB. 1984. Seasonal fluctuations in the prices of coconut, copra and coconut oil in Kerala. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p. 24-31. (CPCRI, Kasaragod, Kerala).

Long term movements in the prices of coconut products are explained to a large extent by the trends in the imports of copra and coconut oil. An attempt has been made here to study the seasonal fluctuations in the prices of coconut, copra and coconut oil. Seasonal indices for coconut oil prices were found to be influenced by the availability of oil in the market, and those for coconut by the demand from copra makers which in turn depended on the pattern of rainfall. The influence of supply factors on the price of coconut was negligible. With increase in prices a shift in the pattern of variation was noticed in the case of coconut. The amplitude of the fluctuations had increased in all cases. Its adverse effect on the small cultivator has been discussed.

35. MISHRA, K.A. 1985. Financing plantation crops; coconut and cashew. *Plr's Chron.* 80(2):77-80. (NABARD, Trivandrum, Kerala).

The near stagnant production of oil seed crops in India and enlarged internal demand leads to increasing oil prices including coconut oil. The Coconut Development Board wants to boost coconut oil production by increasing acreage (which is hardly possible in view of land use), introduction of improved agronomic

practices, replanting of old stands, introduction of irrigation and systematic intercropping with high value crops to support farmers investments in coconut improvement. The adoption of capital intensive technologies is hampered by the poor economic condition of the farmers, small size of holdings, long immature periods and high development costs. State governments assist with interest subsidies to the co-operative sector. However, the Government of India requires a minimum internal rate of return of 15%. Details of project formulation are presented.

36. MOTIAL, V.S. 1988. Role of NABARD in development of coconut plantations and related agroindustries. *Indian Cocon. J.* 19(2):13-14. (NABARD, Worli, Bombay, Maharashtra).

The refinance of credit for coconut development by NABARD covers the activities such as (i) fresh planting; (ii) replanting with high yielding varieties; (iii) rehabilitation of existing plantation; (iv) development of infrastructures like irrigation and land development; (v) establishment of coconut nurseries and production of hybrid coconut seeds. Besides these, NABARD is refinancing for setting up of coconut/coir based small scale industries. The working capital requirements of coconut oil industry and coir industry under co-operative sector are also eligible for refinance.

37. NAGARAJAN, N.; SASTRY, K.N.R. and CHANDRAKANTH, M.G. 1987. Economic considerations in selecting coconut enterprise. *J. Plantn Crops* 15(1):15-22. (Dept. of Agric. Economics, UAS, Bangalore 560 024, Karnataka).

The study throws insights into the factors involved in economics and establishment of coconut garden. In order to examine the profitability and economic feasibility of investment in the enterprise, an attempt was made to compute few measures of project appraisal. The net present worth for the entire

Coconut Oil prices

Plantation crop

Financing NABARD

Cost of Production

project was found to be Rs. 77,167 the discounted benefit cost ratio 1.69 at 12 per cent, the internal rate of return 21.40 per cent and the payback period of 10 years. Since the costs and returns are only the estimates for the advanced period of garden, they may differ from actual results. Accordingly sensitivity analysis was also attempted. These results serve as a yardstick to financial institutions with regard to the unit cost and repayment schedule.

38. NAIR, M.K. and DAS, P.K. 1988. Appropriate technologies for farm women on plantation crops. In Women in agriculture; technological perspectives. Edited by C. Prasad and Shriram. New Delhi: International Federation for Women in Agriculture. p. 100-109. (CPCRI, Kasaragod, Kerala).

Studies on coconut based mixed farming system revealed that two farm women can get full time employment in 1 ha coconut based system raising their income about 3 times in comparison to coconut sole crop system.

39. NAIR, P.B. and JOSEPH, P.N. 1987. Processing and marketing of ball-copra in Andhra Pradesh and Karnataka. *Indian Cocon. J.* 18(8): 7-9. (Coconut Development Board, Cochin, Kerala).

The estimated production of ball-copra in A.P. is around 450 t/year, while it is 30,000 t in Karnataka. The article gives a detailed survey on the processing and marketing aspect of ball-copra in A.P. and Karnataka.

40. NALLATHAMBI, G.; RAVEENDRAN, T.S. and RAMANATHAN, T. 1987. Production costs and returns of coconut cultivar East Coast Tall in Tamil Nadu. *Indian Cocon. J.* 18(10): 13-18. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

The estimated cost for establishing one hectare of coconut plantation was worked out for rainfed and irrigated conditions for the initial

seven year period. The production cost of coconut both under rainfed and irrigated condition was estimated at Rs. 1.18 and 1.10 per unit respectively. The net return was also worked out.

41. NARAYANA, D. and NAIR, K.N. 1989. Trends in area, production and productivity of coconut in Kerala. *Indian J. Agric. Econ.* 44(2):159-167. (Centre for Development Studies, Trivandrum, Kerala).

Factors responsible for the near stagnancy in area and decline in production and productivity of coconuts in Kerala are analysed. The decline in the yield of coconuts in Kerala is attributed to root-wilt disease and the existence of a large proportion of old palms, and is confounded by other factors such as cultivation practices and input use. The spread of cultivation of cocoa, nutmeg and other spices in the last 10-15 years are also factors which need to be taken into account.

42. NAYAR, N.M.; DAS, P.K. and MATHEW, JACOB. 1981. Kerala coconut replanting project. Technical Bulletin no. 4. 8p. (CPCRI, Kasaragod, Kerala).

The production and productivity of coconuts in India in general and in Kerala in particular, are steadily declining. The "Kerala Coconut Replanting Project" (KCRP) aims at planting high yielding coconut seedlings after removing uneconomic palms. As the benefit-cost ratio (BCR) at 17% discounting rate is 1.4 and the internal rate of return (IRR) is 26%, the project is a viable proposition.

43. PANKAJAKSHAN, A.S. 1984. Coconut trade in India. *Indian Cocon. J.* 14(9): 30-37. (Coconut Development Board, Cochin, Kerala).

The production and marketing pattern of some commercially exploited coconut products and by-products in India is reviewed. Future prospects of these products are also

briefed in this article.

44. PANKAJAKSHAN, A.S. 1986. Techno-economic aspects of coconut cultivation. *Indian Cocon. J.* 17(2):8-17. (Coconut Development Board, Cochin, Kerala).

Different aspects of coconut production and industries in India are discussed.

45. RADHAKRISHNAN, V.; RAJINA, S. and PREMAJA, P. 1988. Economics of production and marketing of coconut. In: Six decades of coconut research. Edited by M. Arvindakshan and others. Trichur: Kerala Agricultural University. p. 142-149. (RARS, KAU, Pilicode, Kerala).

Studies taken up in the Kerala Agricultural University on "Economics of production and marketing aspects of coconut" were summarised in this chapter.

46. RAMACHANDRA, B.S. 1987. Economics of hot air drying of wet coconut for oil recovery, possible improvements. *Indian Cocon. J.* 18(2&3): 26-29. (CFTRI, Mysore, Karnataka).

About 3 lakh t of copra is produced for recovery of oil and most of the milling copra is produced by sun drying and kiln drying methods. The copra produced by these two methods is invariably of lower quality when compared to mechanical hot air dried products.

In this paper an attempt has been made to highlight the advantage of mechanical hot air drying to produce good quality milling copra. The cost of production of good quality copra comes to Rs. 6000/t.

47. RATHAKRISHNAN, L. 1989. Price spread in coconut marketing. *Indian Cocon. J.* 19(11):20-22. (Dept. of Economics, Pondicherry University, Pondicherry, 605 003).

Four marketing channels were covered in this study. They are: (i) coconut grower - final consumer; (ii) coconut grower - middle-

man - wholesaler - retailer - final consumer; (iii) coconut grower - wholesaler - retailer - final consumer; and (iv) coconut grower - retailer - final consumer. The gross price spread as percentage of retail price in channel (ii) was 26.67%, in channel (iii) - 31.25% and in channel (iv) - 17.24%.

48. RAVEENDRAN, P. 1983. Behaviour of coconut oil price during 1983. *Indian Cocon. J.* 14(9):43-45. (Coconut Development Board, Cochin, Kerala).

The price of coconut oil reached an all-time high Rs. 3000/100 kg on December 30, '83 in Kerala markets - a rise of Rs. 1050 over that of the corresponding period in 1982. The spurt in price is attributed mainly to a severe shortage of coconut due to failure of both south-west and north-east monsoon in 1982-'83. The ban on the import of tallow is also reported to be an immediate cause for the unprecedented price rise.

49. RAVEENDRAN, P. 1984. Processing and marketing of coconut in Lakshadweep Islands. *Indian Cocon. J.* 14(10): 3-4. (Coconut Development Board, Cochin, Kerala)

Lakshadweep is a group of Islands which has a total extent of 2855/ha coconut, being the major plantation covers an area of 2785/ha which has an annual production around 2.2 crores.

Major varieties grown are Laccadive ordinary (LO) and Laccadive Micro (LM). LO is similar to West Coast Tall variety which gives a copra weight of 120-140 g/nut. LM gives an average of 200 nuts/palm/year. Major products are copra while fibre, vinegar and jaggery are products in small scale. From harvesting to final disposal of copra to mainland the entire operation is a team work comprising owner and a few other men on a profit sharing basis. The marketing of copra is handled by the Lakshadweep Marketing Federation.

50. RAVEENDRAN, P. 1989. Marketing of coconut and its products in Andamans and Nicobar islands. *Indian Cocon. J.* 20(8):14-20. (Coconut Development Board, Cochin, Kerala).

The prices of coconut in the islands rule completely independent of the price movements in the mainland. Moreover, unlike the mainland there was no frequent fluctuations in the prices of coconuts in the islands. The price ruled steady around Rs. 3500/1000 nuts. Major portions of the transactions of the marketed surplus are done through co-operative societies. Copra making is mainly confined to the Nicobar group of islands.

51. RAVEENDRAN, P. 1990. Processing and marketing of coconut and its products in Lakshadweep. *Indian Cocon. J.* 14(10):3-4. (Coconut Development Board, Cochin, Kerala).

Copra is the only product of commercial importance in the islands. Laccadive ordinary cultivar is comparable to the WCT as far as number of nuts is concerned, but it gives slightly less copra (120-140g) per nut. However, Laccadive Micro gives on average 85-95g copra/nut though the yield is as high as 200 nuts/palm/year. Of the production of 220 million nuts in the islands around 20% is consumed locally and the remaining is processed into copra. The copra is transported to mainland before the onset of monsoon by the Lakshadweep Marketing Federation. The annual production of copra is about 1500-1800 t and commercially it is known as Deepayi copra mainly marketed in Mangalore and Calicut.

52. RETHINAM, P. and DAS, P.K. 1983. Cost reduction in coconut production. *In: National Seminar on Cost Reduction in Production Systems, TNAU, Coimbatore.* Proceedings of seminar. p. 53-60. (CPCRI, Kasaragod, Kerala).

Attempts to increase the production

through increasing the productivity alone will help reduce the production cost and there is ample scope for achieving the same in coconut. It is important that only good quality seedlings from the known source are planted and the optimum spacing is adopted. Wherever coconut is grown as a monocrop, raising cover crops may be beneficial not only from the point of saving in weed control programme but also by improving the organic matter status of the soil. Proper fertilizer application based on the soil testing values, skipping phosphorous based on the soil build up, and basin management by growing green manure will help in reducing the cost without detrimental effect to the yield.

53. SHANTHAMALLAIAH, N.R.; JOHN, K.C.; SHANTHAPPA, P.B. and SULLADMATH, V.V. 1978. Factor-product relationship and family labour employment in small coconut gardens of Maidan Tract, Karnataka. *In: Symposium on Plantation Crops, 1st, RRIL, Kottayam, Mar. 2-3, 1978.* Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p. 504-511. (RCRS, UAS, Arsikere-573 103, Karnataka).

The resource use and their allocative efficiency as well as the factors which emerged as the determinant of the family labour use on the small coconut holdings in the Maidan tract of Karnataka State are discussed in this paper.

54. SINGH, R.K.; DAS, P.K. and BHALERAO, M.M. 1984. Some methodological problems in estimating cost of production of plantation crops. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18 1982.* Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p. 66-69. (CPCRI (RC), Mohitnagar, W.B.).

Scientific study on cost of production of plantation crops is of interest to a very wide range of users of cost data and assumes particular importance in planning agricultural strategies.

The methodological problems of estimating the cost of production of plantation crops like coconut are discussed in this paper.

55. SUDHA, M. and REDDY, V.V.R. 1987. Economics of coconut cultivation. *Indian Cocon.* 18(7):20-21. (CRIDA, Hyderabad, A.P.).

A survey on agro-horticultural system involving coconut as one of the perennial fruit trees, was carried out in the dry tracts of Chittoor district of Andhra Pradesh during the year 1985-86. The economics of these systems indicated

a constant return of atleast Rs. 3 on every rupee invested in its cultivation. The cultivators could earn back their investments worth in 9 crop harvests. The possibility of growing leguminous crop like groundnut in the initial years, helps the cultivators earn additional returns from the farm as a unit. The opportunity of taking up fodder and vegetable crops as intercrops even in the later years, makes this system more profitable and economically viable.

## 2. AGRICULTURAL STATISTICS

56. ARULRAJ, S.; NARASIMHAYYA, G.; HAVERI, R.R. and RAJASULOCHANA. 1979. Estimation of coconut yield based on snap observation. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of the PLACROSYM I.* Edited by E.V. Nelliath and others. p. 525. (CPCRI, Kasaragod, Kerala).

Regression analysis of (i) number of buttons less than four months age after the spathe opening (below fist size,  $x_1$ ), (ii) nuts more than four months age after the spathe opening (above fist size,  $x_2$ ) and (iii) bunches ( $x_3$ ), observed during the different months of a year on the total harvested yield ( $y$ ), of nuts during the next calendar year recorded on 43 West Coast Tall palms during their 'stabilised yield' period observed for six consecutive years was undertaken.

The coefficient of determination ( $R^2$ ) of the regression showed progressive increase from January to December and attained a value of around 0.90. This gives a good promise to give a reliable estimate of the yield of nuts harvested in a calendar year based on a single visit in the previous year to observe three easily measurable characters which may probably save man power and funds especially when the palms are located at different places.

57. GEORGE, M.V.; SATHIAMMA, B. and VIJAYAKUMAR, K. 1984. A technique to estimate the field population of coconut leaf eating caterpillar. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982.* Edited by K.V.A. Bavappa and others. Proceedings of PLACROSYM V. p. 638-643. (CPCRI, Kasaragod, Kerala).

The study was carried out with a view to evolving a sampling technique for estimating the population of *Opisina arenosella* Walk one

of the serious pests of the coconut palm in India. Leaflet-wise and leaf-wise counts of the pest were recorded from 50 young palms, for 36 months. The middle leaves and leaflets were found to lodge more number of caterpillars than the other parts of the palm (with minimum C.V.%). Linear regression equations were fitted for estimating the total pest population of a palm by counting the pests in the middle 41-60% of leaflets of the first 20% of leaves from the bottom.

58. GOPALAKRISHNAN, V.; MURUGESAN, M.; SURESH, M. and DHAMU, K.P. 1988. Covariance technique in analysis of experimental data on coconut. *Madras Agric. J.* 75(7-8): 231-233. (Dept. of Statistics, TNAU, Coimbatore, T.N.).

By applying covariance technique, it was determined that the error for mainplot will be more efficient for covariance analysis than error for subplot as far as the residual effects of 'N' application on coconut are concerned. This is true when the coconut yield of previous two or three years are taken as covariates.

59. MATHEW, JACOB. 1988. Statistical techniques for experiments with coconut. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Nov. 23-26, 1988. Abstracts of papers.* p.39. (CPCRI, Kasaragod, Kerala).

The statistical techniques followed in experiments with annual crops and perennial crops are essentially the same. However, while experimenting with perennial crops, the problems faced with, are somewhat different from those with annual crops. Difficulties arise because of the perennial nature of the crops, long duration of experiments, large size of the plots, lack of uniformity in the experimental

material, differences in the pre-bearing period coupled with long bearing period, time lag between application for treatments and manifestation of their effects etc. Among perennial crops, coconut gives yield throughout the year unlike in many other crops. Recent studies have shown that the annual yield data of coconuts followed a skewed distribution, thus necessitating suitable transformations, to satisfy some of the assumptions involved in the statistical analysis of data. Conclusions drawn from experiments can also differ, depending on the method of compilation of annual yield data. Year to year variation is more pronounced in the case of calendar year tabulation as against agricultural year.

60. MATHEW, JACOB and VIJAYAKUMAR, K. 1984. Some considerations in analysis of the yield data of coconut. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p. 32-40. (CPCRI, Kasaragod, Kerala).*

Examination of yield data of coconut for individual years revealed that the distribution is always positively skewed and leptokurtic. Pooling the data for consecutive years as well as consideration of palms in groups did not improve the distribution. Among the different transformations tried  $\sqrt{x+10}$  transformation was found to bring the data to a near normal distribution in most cases. Another difficulty experienced while analysing the yield data of coconut experiments is the large error variance. With pooling of data for consecutive years, variance was found to get reduced. Covariance analysis was found to result in the increased efficiency.

61. MATHEW, JACOB; GOPALASUNDARAM, P.; GEORGE, M.V.; KUMAR, K.V. and JOSE, C.T. 1989. Crop year versus calendar year as basis for compiling annual yield in coconut. *J. Plantn Crops 16(Suppl.):475-479. (CPCRI, Kasaragod,*

Kerala).

In coconut, the annual yield is taken as the number of nuts harvested at 30 to 60 day intervals over 12 months. Year-to-year variations were more pronounced where yield data were related to the calendar year than when they were related to the crop year (July to June). When 2 year average were taken, differences between years and between recording methods were reduced.

62. NAIR, B.P. and GOPINATHAN UNNITHAN, V.K. 1986. Forecasting models to estimate annual coconut yield based on monthly weather. *In: Workshop on Impact of Drought on Plantation Crops, CPCRI, Kasaragod, May 26-27, 1986. Extended summaries. p.10-12. (CPCRI, Kasaragod, Kerala).*

Attempts were made to forecast annual yield of coconut using monthwise climatic factors (numbering 18) using 2 methods. For this purpose, yield data from 167 WCT palms in the age group of 45-50 years, growing under rainfed condition and recommended doses of fertilizers management from CPCRI, Kasaragod was made use of. The method based on stepwise regression analysis ( $R^2=0.85$ ) and Principal component analysis ( $R^2=0.82$ ) were equally good in forecasting annual yield.

63. NAMBIAR, P.T.N. 1989. Optimum plot size for WCT coconut palms from fertilizer trial yield data. *J. Plantn Crops 16(Suppl.):489-492. (CPCRI, Kasaragod, Kerala).*

The yield data from an NPK fertilizer experiment were used to study the coefficients of variations for plots of different size and shape. No great variations in CV were found for plots of different shape but equal size. The CV decreased with increasing plot size and Smith's Law (Journal of Agricultural Science (1938) 28, 1-23) gave a satisfactory fit to the underlying relationship between CV and plot size. The per unit decrease in CV were minimum when

the plot size exceeded 8 palms.

64. PRABHAKARAN, P.V.; BALACHANDRAN NAIR, G.K.; PADMANABHAN THAMPI, A.; SIVASANKARA PILLAI, K.; RAMACHANDRAN NAIR, V.; MADHAVAN NAIR, G.; PUSHPANGADAN K.; SUKUMARAN, K.M.; RAGHAVAN PILLAI, G. and KOSHY, E.P. 1988. Forecast of coconut yield using biometric characters of young palms. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Nov. 23-26, 1988. Abstracts of papers. p. 40. (Coconut Res. Station, KAU, Balaramapuram, Kerala).*

Correlation and path coefficient analysis of various growth characters of young coconut palms of the age group 4-7 years with long term yield of coconut revealed that number of leaves was the major contributor towards variations in the nut yield of coconut. Selection of palms for nut yield could be done effectively on the basis of number of functioning leaves as early as in the sixth year after planting. Prediction equations were evolved for making advance estimates of probable production from young palms based on the morphological traits assuming a more or less constant environment to continue in the orchard. An attempt was also made to find the desirable characteristics of pre-potent palms to be identified as parents for further breeding. It was found that selection of plants for leaf number and leaf production rate at early stages would be a quick method of genetic improvement. Replacement or rejuvenation of undesirable young palms with sufficiently lesser number of leaves should be an important aspect of effective farm management.

65. SARASWATHI, P. and KRISHNAN, K.S. 1989. Field plot technique for experiments with coconut. *J. Plantn Crops* 16(Suppl.): 481-487. (College of Agric., KAU, Trivandrum, Kerala).

Problems concerning the lay out of

experiments on coconuts and statistical analysis of the data are discussed. Achieving greater homogeneity between plots within a block by increasing heterogeneity within the plots was found to be the best design approach.

66. THAMPAN, P.K. and PANKAJAKSHAN, A.S. 1981. Two decades of coconut development in India; a review. *Indian Cocon. J.* 11(12): 1-7. (Directorate of Coconut Development, Cochin, Kerala)

A brief description of the development of the coconut industry is given. Steady increase of the area under coconut since 1955 up to 1979 are tabulated together with production. Comparative study is presented with regard to the production of coconut oil and vegetable oils.

67. VIJAYAKUMAR, K.; MATHEW, JACOB and SUKUMARAN, C.K. 1991. Discriminant function analysis in coconut seedlings. *J. Plantn Crops* 17(Suppl.): 373-375. (CPCRI, Kasaragod, Kerala).

Data on 192 seedlings from 16 families of West Coast Tall variety were utilised for constructing a discriminant function for classifying seedlings into high/low yielders at the nursery stage using 11 seedlings characters. Time taken for flowering was adopted to judge a palm as high/low yielding. The function based on this criterion was significant. Girth, number of leaves, weight of the seedling and number of thick roots were found to contribute maximum in discriminating between potentially high/low yielders.

68. VIJAYAKUMAR, K.; NAMBIAR, P.T.N.; MATHEW, JACOB; AMARNATH, C.H. and BALAKRISHNAN, T.K. 1989. Forecasting of yield in coconut by using weather variables. *J. Plantn Crops* 16(Suppl.): 463-468. (CPCRI, Kasaragod, Kerala).

The influence of monthly averages of 11

weather variables was studied using 2 sets of data for the period 1955-1982. The following were identified as important for yield prediction- relative humidity, (F.N.) sunshine hours, and vapour pressure (F.N.) for weeks 17-20 one year earlier, temperature (minimum) for weeks

21-24, and (F.N.) humidity for weeks 25-28, 2 years earlier; and temperature (minimum) for weeks 29-32, 3 years earlier. The prediction model developed could explain 91% of the variation in yield.

### 3. AGRONOMY

69. ANANDARAJ, M.; SIVARAMAN, K. and KRISHNAMOORTHY, B. 1989. Effect of weed control through weedicides in plantation crops. *Indian Cocoa, Arecanut & Spices J.* 13(2):63-64. (NRCS, Calicut, Kerala).

In trials on a coconut-nutmeg plot in Kerala, during 1987-88, weeds were slashed to ground level and herbicides were sprayed after 10 days of weed regrowth. Paraquat (2.25 kg/ha), 2, 4-D (2.25 kg/ha) and a mixture of paraquat (2.25 kg/ha) +2, 4-D (2.25 kg/ha) were applied once. In a 4th treatment there was a spot application of the mixture after 45 days. Wilting of the weeds started after 24 hours and complete drying occurred after 72 hours. No weeds were present in the paraquat +2, 4-D plot after 2 months. Weed regrowth after 6 months was between 90% (2, 4-D) and 3% (paraquat +2, 4-D) with 2nd spot application.

70. ARAVINDAKSHAN, M. 1988. Thrust areas in coconut management. *In National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988.* Abstracts of papers. p.25-26. (KAU, Trichur, Kerala).

The productivity of coconut in India is 30 nuts per palm per year against the potential of more than 100 nuts per palm per year. Yield of the crop in major coconut growing states being 33, 44 and 54 nuts per palm per year in Kerala, Tamil Nadu and Karnataka respectively and is far from satisfactory. There is a dire need to improve the productivity of the palm in the present context of rising oil imports to meet the ever increasing domestic needs.

71. BALACHANDRAN NAIR, G.K.; VIJAYAN, M.; SARASWATHI, P.; PADMANABHAN THAMPI, P.; SIVASANKARA PILLAI, K.; RAMACHANDRAN

NAIR, V.; MADHAVAN NAIR, G.; PUSHPAN-GADAN, K.; SUKUMARAN, K.M.; RAGHAVAN PILLAI, G. and KOSHY E.P. 1988. Effect of spacing and manuring on the nut production in coconut. *In National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988.* Abstracts of papers. p.36. (Coconut Res. Station, KAU, Balaramapuram, Trivandrum, Kerala).

Analysis of the cumulative average yield of palm for a period of twelve years from 1976 to 1987, recorded from a spacing cum manurial trial conducted at the Coconut Research Station, Balaramapuram, Trivandrum, Kerala showed significant interaction between spacing and manuring. The cumulative yield of nuts per palm increased by 457 and 621 nuts respectively by the application of 340 g N, 225 g P<sub>2</sub>O<sub>5</sub> and 450 g K<sub>2</sub>O and double the above quantity of fertiliser per palm per year. An increase in spacing was also found to increase the individual palm yield but decreased the per hectare production. The yield was increased by 307 and 373 nuts at the spacing of 7.5 x 7.5 m and 10 x 10 m respectively in comparison with 5 x 5 m spacing. However, the difference in yield at spacings 7.5 x 7.5 m and 10 x 10 m was not significant.

72. BALAKRISHNAN, P.C.; RAO, G.S.L.H.V. PRASADA and NAIR, R.R. 1988. Heat unit requirement for germination of coconut cultivar West Coast Tall; a preliminary study. *In National Seminar on Agrometeorology of Plantation Crops, KAU, Vellanikkara, Trichur, Mar. 12-13, 1987.* Proceedings of seminar. p.79-80. (RARS, KAU, Pilicode, Kerala).

An attempt was made to study the heat unit requirement for germination of seednuts of the coconut cultivar West Coast Tall at the

RARS, Pilicode during the year 1985. The heat unit requirement for 50%, 70% and 90% germination of seed nuts were 1721 day C, 1883 day C and 2216 day C, respectively.

73. BALASUBRAMANIAN, R.; RAMANATHAN, T. and VIJAYARAGHAVAN, H. 1985. Certain aspects of moisture conservation in coconut gardens. *Indian Cocon. J.* 16(2):13-15. (TNAU, Coimbatore, T.N.).

Moisture conservation by different mulching materials has been investigated in bearing adult coconut plantations. Different mulching materials which are locally available such as coconut husks, fodder trash, coconut leaves and palmyrah leaves were tried in a rainfed coconut garden in order to find out a suitable mulching material. Burying coconut husks and leaves in trenches between the rows of palms increased the yield by 44.6% over control. The coconut husks and leaves conserved the moisture to the maximum level.

74. BALASUBRAMANIAN, R.; RAMANATHAN, T. and VIJAYARAGHAVAN, H. 1985. Effect of chemical weed killers versus cultural operations on weed growth and yield of coconut. *Indian Cocon. J.* 16(4):17-20. (TNAU, Coimbatore, T.N.).

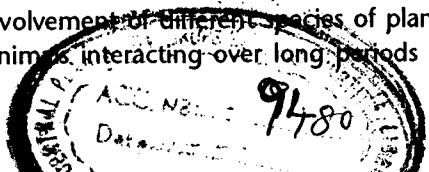
In a 5-year study with East Coast Tall palms, Dalapon at 2 kg/220 litre of water/acre, Gramoxone (Paraquat) @ 1l + Fernoxone (dichlorprop) @ 0.5 kg/200 l water/acre of Karmex (diuron) @ 1 kg/200 l water/acre controlled weed growth in increasing order of effectiveness, but failed to improve yields. Herbicide application was compared with half yearly ploughing of the entire area. Ploughing the entire area produced the highest nut yield (21% higher mean yield than untreated control) presumably as a result of reduced weed growth and increased moisture infiltration and gave the lowest cost/profit ratio. Herbicide application was considered uneconomic.

75. BAVAPPA, K.V.A. 1990. Agronomic desirability of coconut based farming systems. In COCOTECH Meeting on Coconut Based Farming Systems, 27th, Manila, Philippines, Jun. 25-29, 1990. Proceedings of the meeting. p.57-68. (FAO, Hochiminh City, Vietnam).

Though coconut based farming system in some form or other has been in vogue in different coconut growing regions of the world, scientific information on the desirability or otherwise of such systems has been meagre. Research efforts made during the last two decades have shown that coconut crop is amenable for adopting farming systems. Systems designed on sound scientific principles of land space and solar energy utilization and managed under normal conditions with adequate inputs recorded higher production of both biomass and economic yield. The systems had buffering effect against drastic fluctuations in the ecoclimate. Improvement in soil fertility status and enhanced water use efficiency had also been indicated. There was increased microbial activity in the rhizosphere of the component crops and increase in the population of beneficial micro-organisms and microbial biomass. The scope for adopting a no tillage farming technology was apparent. These agronomic desirabilities of coconut based farming systems are reviewed and potentials available for better exploitation of the systems discussed.

76. BAVAPPA, K.V.A. 1990. Management of coconut based farming systems. In: COCOTECH Meeting on Coconut Based Farming Systems, 27th, Manila, Philippines, Jun. 25-29, 1990. Proceedings of the meeting. p.491-500. (FAO, Hochiminh City, Vietnam).

Unlike monocrop of coconut, the management needs of coconut based farming systems are diverse and complex because of the involvement of different species of plants and animals interacting over long periods of



time. Though wide choices of crops and animals are available as components of the farming system, their correct choice keeping in view the soil and climatic conditions and their compatibility is the first management consideration that will contribute to the success of the system. Method of planting and the planting density of coconut as well as that of component crops, time of planting, crop rotation for control and economy in fertilizer use, canopy management for better light transmission, recycling biomass at high density integrated farming system levels, employment generation potential of the systems and its effect on labour availability in peak seasons of agricultural operations, post harvest processing needs of the component crops and marketing infrastructure for products arising out of farming systems adopted are some of the management problems requiring careful attention. These as well as a restructuring approach to improve the productivity of the traditional farming systems are presented in this paper.

77. BAVAPPA, K.V.A. 1990. An upto date research profile on coconut based farming systems. In *COCOTECH Meeting on Coconut Based Farming Systems, 27th, Manila, Philippines, Jun. 25-29, 1990*. Proceedings of the meeting. p.90-102. (FAO, Hochiminh City, Vietnam).

Research on coconut based farming systems is still in its infancy. The observation made in many of the coconut growing countries that light transmission in coconut plantations is generally over 40% focused the attention of researchers to undertake mixed cropping trials with a variety of annual crops and perennials. Results from root studies on coconut and its growth habit enabled planning of farming trials with better rationale. From the trials conducted so far in India, Philippines, Sri Lanka, Malaysia and Western Samoa, tubers (cassava, taro, elephant foot yam, lesser yam), rhizome spices (ginger, turmeric) vegetables (chilli,

cabbage, cauliflower, tomato, shallots) and fruits (banana, pineapple, passion fruit) and other crops like robusta coffee, black pepper, cinnamon, clove and cocoa are found to be the more important crops that could be successfully grown in coconut land. The better yield performance of coconut-cocoa, coconut-cocoa-pepper-pineapple and coconut based high density systems and the favourable ecoclimate and soil changes that were observed in these systems have given some insight into the dynamics of the farming systems. The integrated coconut-grass-cattle system with recycling of cattle waste and production of biogas has high employment potential and income generation capability. In the light of the available information on Coconut Based Farming Systems, the research profile is discussed so as to bring out priority areas of the future.

78. BHASKARAN, U.P. and LEELA, K. 1977. Water management in coconut. *Indian Cocon. J.* 8(5):1-4. (KAU, Trichur, Kerala).

A review on agro-climatic conditions, crop habit and adaptability, weather factors and yield response to irrigation, water management in soils with fluctuating water tables, response to salt water irrigation, response of young seedlings to irrigation, water requirement of the palm, moisture conservation practices, and associated problems are discussed.

79. BHASKARAN, U.P. and LEELA, K. 1978. Response of coconut to irrigation in relation to production status of palms and soil type. In *Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar 20-23, 1978*. Proceedings of PLACROSYMI. Edited by E.V. Nelliat and others. p.200-206. (KAU, Trichur, Kerala).

An annual yield increase of 31 nuts per palm is observed due to supplementary basin irrigation given during summer months to coconuts grown in red sandy loam soil. Among different yield groups, maximum response was

given by 'low yield groups'. The palms in the high yield groups failed to show parallel response as observed in the palms in the low yield groups; probably the nutrients are limiting their yield responses which are already high even under normal conditions. About 50 per cent of the yield increase is achieved during the 'transit period of production' comprising first 3 years. Increase in female flower production and setting percentage were high in the bunches harvested during North East monsoon and South West monsoon periods respectively. In littoral sand, significant increase in functional leaves and yield were recorded under flood irrigation. Flood irrigation is preferred to basin irrigation in littoral sand. The cost benefit ratio of irrigation was estimated as 1:3.

80. BHASKARAN, U.P. and LEELA, K. 1983. Seasonal influence on yield of Tall x Dwarf and West Coast Tall coconuts in Kerala, India. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 28-31, 1976, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.136-143. (College of Horticulture, KAU, Trichur, Kerala).

In the tropical monsoon climate of Kerala, annual rainfall and coconut production show distinct seasonal fluctuations. Seasonal variations in yield and nut character are attributed to the cyclic influence of varying seasons on different critical stages during the spadix development. Seasonal rains affecting spadix growth at five critical stages are found to influence the yields in different seasons of succeeding four years. Temperature, humidity, wind, and sunshine hours have only conjoint influence with the main effects of rainfall on yield. Effect of seasonal rains is more pronounced in Tall x Dwarf indicating that this cultivar is more sensitive to low and erratic rainfall. Ultimate cause effect analysis indicates that coconut yield is related to soil moisture status, and that by providing optimal moisture in critical stages stabilisation and enhancement

of seasonal yields are possible.

81. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD. 1987. Drip irrigation for coconut. Extension Pamphlet no.31. 8 p. (CPCRI, Kasaragod, Kerala).

The bulletin describes advantages of drip irrigation and various components for designing a cheap and low pressure drip irrigation system most suited to home-stead coconut garden alongwith the approximate cost of installation.

82. DAS, P.K.; YUSUF, MOHAMED and HEGDE, M.R. 1991. Reducing the risks in rainfed coconut cultivation. *Indian Fmg* 40(10):29-34. (CPCRI, Kasaragod, Kerala).

This paper highlights the sound conventional and nonconventional practices which are aimed at reducing risks in rainfed coconuts by improving the soil physical properties, enhancing the nutrient status and conserving moisture.

83. GOPALASUNDARAM, P. 1986. Effect of depth and frequency of irrigation water and fertilizer level on growth and yield of coconut. In Workshop on Impact of Drought on Plantation Crops, CPCRI, Kasaragod, May 26-27, 1986. Extended summaries. p.53-54. (CPCRI, Kasaragod, Kerala).

The cumulative yield of coconut palms since bearing was significantly influenced by the main effects viz., depth (D), frequency (f) of irrigation, fertilizer levels (m) and D x f and f x m interactions. Irrigation with 20 mm water at IW/CPE - 1.00 produced highest number of nuts (918) per palm followed by same quantity of water at IW/CPE=0.75 (872 nuts). IW/CPE=1.00 at  $m_2$  level (750 gN+670 g P<sub>2</sub>O<sub>5</sub>+1500 g K<sub>2</sub>O+170 g MgO) recorded higher production whereas IW/CPE ratio of 0.75 produced higher nuts at  $m_3$  level (100 gN+100 g P<sub>2</sub>O<sub>5</sub> + 2250 g K<sub>2</sub>O +170 g MgO/palm yr of fertilizer.

84. JOSHI, O.P.; GOPALASUNDARAM, P. and YUSUF, MOHAMED. 1987. Moisture depletion pattern in coconut plantation under rainfed and irrigation conditions. In: National Seminar on Agrometeorology of Plantation Crops, RARS, Pilicode, Mar. 12-13, 1987. Proceedings of seminar. p.22-26. (CPCRI, Kasaragod, Kerala).

Under rainfed conditions, the evapotranspiration was about 4 mm/day during the first two days of receipt of rains. This gradually reduced to 2.4 and 2.1 mm/day after one and two weeks of rains. The maximum contribution of water to coconut palms is from 0-70 cm layer. In general water loss from the interspaces was higher than the basins. Under irrigated condition, maximum evapotranspiration (6.6 mm/day) and water loss from the interspaces (5.6 mm/day) were recorded with 20 mm water at IW/CPE ratio of 1.00. Decreasing frequency gradually decreased the rates to 4.0 mm and 2.3 mm/day at IW/CPE ratio of 0.75 and 0.50 respectively from 0-90 cm soil depth. Irrigation with 20 mm of water at IW/CPE ratio of 1.00 is adequate to meet the water needs of coconut palms for optimum growth. A higher quantity is not desirable as it lead to deep percolation loss.

85. JOSHI, O.P.; NAMBIAR, C.K.B. and KHAN, H. HAMEED. 1982. Effect of organic manuring on some physical properties and water retention of coastal sand. *Philipp. J. Cocon. Studies* 7(1-2):42-46. (CPCRI, Kasaragod, Kerala).

Effects of applying coir dust, coconut shreadings forest leaves and cattle manure as organic fertilizer on some physical properties of littoral sand were investigated in this study. The incorporation of organic sources blended with inorganic nutrients continuously for 10 years was found to increase the water holding capacity and decrease the bulk density of the soil as compared to the application of inorganics alone. The saturated hydraulic conductivity was higher in soil samples from the basins of

palms treated with organic manure. An improvement in water retention characteristics and available water capacity was also observed on account of coupling of organic sources with inorganic fertilizers. The available water capacity of 0.78 per cent by weight for plots treated with NPK alone increased to 1.94, 0.87, 1.39, and 1.13 per cent when coir dust, coconut shreadings, forest leaves, and cattle manure, respectively were incorporated alongwith NPK.

86. KANNAN, K. 1981. Preliminary studies on underplanting in coconut garden. *Indian Cocon. J.* 11(10):2-4. (Coconut Res. Station, KAU, Pilicode, Kerala).

Underplanting was done in a 52 year old coconut plantation spaced at 9 m in triangular method of planting with different coconut hybrids and varieties. No yield reduction was noticed in the old stands 4 years after underplanting. The underplanted seedlings are also made comparatively better growth.

87. KANNAN, K.; NARAYANAN NAMBIAR, P.K. and NAMBIAR, K.P.P. 1977. Studies on spacing in coconut. *Indian Cocon. J.* 8(2):1-2. (Coconut Res. Station, KAU, Pilicode, Kerala).

West Coast Tall coconut palms were planted at 60, 80 and 100 palms/acre. While the spacing had no appreciable effect on the yield of individual palms, the yield/acre was highest from plots with 100 palms/acre.

88. KUMAR, A.S.A. and PILLAI, S.J. 1990. Germination, seedling vigour and recovery of quality seedlings as influenced by pre-sowing preparations of seed coconuts. *Indian Cocon. J.* 20(10):6-7. (College of Agric., KAU, Trichur, 680 654, Kerala).

Six pre-sowing treatments were compared for germination percentage, seedlings height, number of leaves, girth at collar and the percentage of total high quality seedlings. Sowing the seednuts after dehusking and

covering them with the husk of the same nuts gave the highest germination (84.8%) after 8 months and the greatest number of high-quality seedlings (75%).

89. LOUIS, I. HENRY. 1988. The right method to plant coconut seedlings. *Agric. Bull.* (Salem) 37-88:11. (Coconut Res. Station, TNAU, Veppankulam, T.N.)

The seedlings may be judged for their vigour based on the number of leaves per year. The seventh leaf in a tall ecotype should normally split. The pit dug should be 3' x 3' x 3', to hold the bole of an adult palm. While planting it is good to provide shade at least for three months.

90. LOUIS, I. HENRY. 1989. Studies on root system in coconut palm. *Indian Cocon. J.* 19(12):12. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

The influence of root system with reference to planting depth has been reported. The primary, secondary and tertiary roots with pnuematophores on them are concentrated within a radius of 2 meters from the stem. Planting at a depth of 1 meter therefore is assumed ideal.

91. LOUIS, I. HENRY and ANNAPPAN, R.S. 1982. Transplanting of grown up coconut palm. *Indian Cocon. J.* 13(8):1-6. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Transplanting of fully grown coconut palm is an age old practice. Trimming of the roots, reducing the area of transpiration by cutting most of the unfurled leaves, (allowing the central bud with 3 to 5 leaves), careful transportation of the uprooted palm to the new site etc. are very important steps. The size of the pits for transplanting adult palm has to be 4' x 4' x 4'. Provision of moisture and calculated quantum of nutrients at the root zone form the prime measures in the after care procedures.

92. LOUIS, I. HENRY and ANNAPPAN, R.S. 1986. Environmental effects on yield of coconut palms. *Indian Cocon. J.* 10(12):1-3. (Coconut Res. Station, TNAU, Veppankulam, T.N.)

The study on the trend of yield in steady bearing palms revealed that temperature and humidity are highly correlated with yield of nuts. Significant variation could be found in the yield during the four different seasons of the year, the maximum yield being obtained during the summer months. The inherent differential yielding potentiality of the palms not only suggests the immense possibility of narrowing the genetic gap existing within a variety by way of suitable selection for yield but also the importance of selecting and planting only quality seedlings for yield.

93. LOUIS, I. HENRY and BALASUBRAMANIAN, K. 1983. Effect of cultural practices, irrigation and manuring on the development of root systems in the coconut palm. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.293-295. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Only about 3% of the roots were in the top 30 cm depth of the soil. As much as 60% of the roots were in the 31-60 cm depth zone. The distribution of respiratory roots on primary roots was studied. They were considerably less in all the plots receiving cultural treatments. The present study revealed that root growth and development are highly variable characters.

94. LOUIS, I. HENRY and CHANDRASEKHARAN, N.R. 1983. Effect of interculture, irrigation and manuring on coconut in Tamil Nadu, India. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.93-

97. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

The effect of two levels each of cultural, manurial and irrigational operations on growth characters and yield of nuts was studied at three and eight years of age in a field experiment laid out in a split plot design with three replications. At three years, manuring increased height, girth at collar, number of leaves per year, number of leaves on the crown, length of leaves and number of leaflets per leaf. Irrigation produced significant increase in height of palms. Cultural operations either alone or in combination with irrigation or manure did not have any effect on growth characters.

At eight years, manuring and irrigation together increased number of leaves and length of stem. Early and uniform flowering and increased yield of nuts per palms were also observed in these treatments. Irrigation alone increased number of leaves but cultural operations did not produce any significant effect on any of the characters. Interaction was observed only between manure and genotype on the production of leaf.

95. LOUIS I, HENRY; CHANDRASEKHARAN, N.R.; VENKATESWARAN, A.N. and VIJAYAN, K.P. 1980. Note on the effect of summer irrigation on the dwarf varieties of coconut palm. *Indian Cocon. J.* 11(7): 5-6. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

A study to assess the effect of summer irrigation on the growth and production of three Malayan Dwarf cultivars has shown that irrigation at fortnightly intervals, during the summer months increased the production of female flowers, setting percentage and yield of nuts in all the three cultivars but the increase was markedly higher under the normal irrigation. The highest response was obtained in the Malayan Yellow Dwarf followed by Malayan Red Dwarf.

96. LOUIS, I. HENRY, KRISHNASWAMY, V.; VENKATESWARAN, A.N. and VIJAYAN, K.P. 1981. Effect of spacing and manuring on coconut palms in the east coast of Tamil Nadu. *Indian Cocon. J.* 12(1): 1-5. (Cocon. Res. Station, TNAU, Veppankulam, T.N.).

Long-term trials were carried out with the coconut cv. East Coast Tall spaced at 6.1 x 6.1 m, 7.6 x 7.6m and 9.1 x 9.1m. N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were applied at 45-340: 45-227: 90-454 g/palm per year (single dose) or 90-680, 90-454: 180-908 g/palm per year (double dose). Data are tabulated on the effects of treatments on the root system, trunk girth, trunk height, number of leaves, flowering, fruit set and nut yield. Mean yield for the years 1973-1977 was highest (9078 nuts/ha) from the closely spaced plots receiving double NPK rates.

97. MATHAI, G. 1979. Effect of cultural practices on the yield of coconut palm. *Indian Cocon. J.* 10(5):1-2. (Coconut Res. Station, KAU, Kumarakom, Kerala).

In a trial with mature West Coast Tall coconuts the effects were compared of intercultivation by hand twice a year, scraping the soil surface clean of grass at 30 day intervals during the rainy season and at 45 day intervals during dry periods and growing a cover crop of *Pueraria javanica*, and a grass over (control). The treatments were given for 6 years until 1967 and the yields were recorded from 1965 to 1968. The highest average yields/year were obtained with clean scrapping of the soil surface and intercultivation (43 and 41 nuts/palm, respectively) compared with 29 nuts/palm from controls.

98. MATHAI, G. and PANICKER, K.S. 1978. A note on the relationship between yield of coconut and rainfall pattern in the back water region of Kerala. *Agric. Res. J. Kerala* 16(2):253-255. (Coconut Res. Station, Kumarakaom,

Kottayam, Kerala).

The rainfall received in the backwater region of Kerala is correlated with the yield of nuts of coconut palms. It was found that yield of coconuts was unaffected by the relative pattern of rainfall occurring in the region.

99. MATHEW, CHACKO. 1979. Conservation of soil moisture helps to increase coconut yield. *Indian Cocon. J.* 10(8):5-6. (CPCRI (RS), Kayangulam, Kerala).

The proper growth and productivity of the coconut palm depend to a large extent on the availability of sufficient moisture content in the soil. Scientific cultivation of coconut definitely warrants proper care and suitable management practices, designed to conserve maximum soil moisture. Only under adequate and continuous supply of soil moisture sustained high yield can be obtained from the coconut palm.

100. MATHEW, M.T. and HEMACHANDRA. 1990. Water management: a pre-requisite for coconut gardens in Tamil Nadu. *Indian Cocon. J.* 20(11): 11-17. (Coconut Development Board Regional Centre, Thanjavur, T.N.).

Tamil Nadu ranks 3rd among Indian states in area under coconuts and 2nd in production of coconut. Since the average annual rainfall ranges from 700 to 1500 mm with only 40-70 rainy days/year, irrigation of the crop is of economic importance. The water management is discussed under the headings monsoon management, aquifer or ground water management and wetland management. Tabulated data are presented on area and production of coconuts in 17 districts of Tamil Nadu, showing monthly and annual rainfall in these districts.

101. MOHANDAS, S.; PANCHANATHAN, R.M.; KULANDAIVELU, R. and KANDASWAMY, P. 1989. Assessment of crop water requirement

for coconut. *Indian Cocon. J.* 20(1):10-11. (Water Technology Centre, TNAU, Coimbatore, T.N.).

An estimate of crop water requirement of coconut was made following a new approach viz., crop evapotranspiration (CET). Relating this estimate with evaporation from an open pan evaporimeter on a day, daily crop water requirement for a palm was worked out for different months.

102. NAIR, M.K. and GOPALASUNDARAM, P. 1990. Coconut based farm family models in India. In: *COCOTECH Meeting on Coconut Based Farming Systems, 27th, Manila, Philippines, Jun. 25-29, 1990*. Proceedings of the meeting. Edited by Sumit de Silva. p.360-389. (CPCRI, Kasaragod, Kerala).

Coconut provides opportunities to grow a wide range of crops in the inter spaces for maximising productivity from unit area of land per unit time. The crops will have to be selected carefully so that the farmer derives the maximum advantage with lower inputs, increased employment opportunities for family labour and high net returns. A lot of research is needed to understand the various inter/intra species interactions among plants, input requirement for different systems identification of new crop combinations and screening of new crop/ varieties for their shade tolerance.

103. NAIR, R.R. 1989. Summer irrigation requirement of the coconut palm. *Indian Cocon. J.* 19(12):3-7. (RARS, KAU, Kumarakom, Kottayam, Kerala).

A review of effect of moisture stress on yield; water requirement of coconut, response to irrigation; irrigation fertilizer interaction; response of young coconut seedlings to irrigation; irrigation with saline water; moisture conservation practices; water management in areas having high water table; and problems associated with irrigation, are discussed.

104. NAIR, R.R.; PILLAI, G.R. and RAJAGOPALAN, A. 1988. Water management in coconut. *In: Six decades of coconut research.* Edited by M. Aravindakshan and others. Trichur: Kerala Agricultural University. p.44-103. (RARS, KAU, Kumarakom, Kottayam, Kerala).

Work done on water management aspects in coconut by the Kerala Agricultural University is highlighted in this Chapter.

105. NALLATHAMBI, G.; RAMANATHAN, T. and MANMOHAN LAL, S. 1988. Effect of various organic manures on the yield of East Coast Tall coconut. *Indian Cocon. J.* 19(2):3-5, (RARS, Veppankulam, TNAU, T.N.).

Experiments were conducted with equal nutrients supply from various organic manures on ECT cultivar from 1981 to 1985 at Coconut Research Station, Veppankulam. The percent increase in nut yield was 53 and 54 in FYM and green manure treatments respectively over the control. The fruit components of coconut were not influenced by any of the treatments. Maximum copra (120 g/nut) with 18% increase over the control was recorded only in FYM treated palms.

106. NAMBIAR, I.P.S. and SASIDHARAN, N.K. 1988. Cultural practices in coconut. *In: Six decades of coconut research.* Edited by M. Aravindakshan and others. Trichur: Kerala Agricultural University. p.37-46. (RARS, Pilicode, Kerala).

Research conducted on cultural practices in coconut by research stations which are at present in the Kerala Agricultural University was summarised in this chapter.

107. NAMBIAR, I.P.S.; NAMBIAR, P.K.R. and RAJAN, K.C. 1988. Coconut based cropping systems. *In: Six decades of coconut research.* Edited by M. Aravindakshan and others. Trichur: Kerala Agricultural University. p.137-142. (RARS, Pilicode, Kerala).

Research conducted on coconut based cropping systems by Research stations which are at present under the Kerala Agricultural University was summarised in this chapter.

108. NELLIAT, E.V. 1983. Nutritional requirement of coconut genotypes. *South Indian Hort.* (Commem. Iss.):109-113. (CPCRI, Kasaragod, Kerala).

Three high yielding lines were grown without fertilizer and with total annual doses/palm of 500:500:500 and 1000:1000:2000 g N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O. Considerable variation in response to treatment was found. CODxWCT was more productive than WCTxCOD and WCT.

109. NELLIAT, E.V. and GOPALASUNDARAM, P. 1984. Input management for obtaining targetted yield in coconut. *Indian Cocon. J.* 15(3-4):41-46. (CPCRI, Kasaragod, Kerala).

It is found that there is a possibility to adjust the management practices to obtain desired yield levels. Yields ranging from 13 nuts/palm/year to 60-65 nuts could be obtained from WCT palms under rainfed conditions. Ordinary tall palms can yield 95-100 nuts/palm/year with summer irrigation and good management. CODxWCT hybrid is capable of yielding 80-90 nuts/palm/year in north Kerala region under rainfed conditions and good management; but the same hybrid gives yields of over 110 nuts/palm/year in South Kerala where the rainfall distribution is more favourable. Still higher yields could be obtained from the hybrid under irrigated conditions. More income per unit area of land and higher yield from coconut can be obtained by raising inter/mixed crops and by adopting multistoreyed cropping and mixed farming systems.

110. NELLIAT, E.V.; GOPALASUNDARAM, P.; SIVARAMAN, K. and NAIR, R.V. 1984. Fertilizer management for coconut grown under neglect. *In Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982.* Proceedings of

PLACROSYM V, Edited by K.V.A. Bavappa and others. p.375-387. (CPCRI, Kasaragod, Kerala).

An experiment was conducted from 1973 to 1980 in a 20-year old coconut garden near CPCRI, Kasaragod to work out the fertilizer schedule for the quick revival of West Coast Tall palms grown under neglected condition. The study revealed that application of double the recommended annual dose of fertilizers in the first one or two years, followed by the recommended dose of 500g N+320g P<sub>2</sub>O<sub>5</sub>+1200g K<sub>2</sub>O/palm/year in subsequent years, resulted in the earlier response and higher cumulative yield of nuts than the application in one-third, half or recommended dose in the first year followed by the recommended dose in later years. It also gave an additional return of Rs. 21,754/ha over the farmer's practice and Rs. 854/ha over the standard dose from the beginning.

111. NELLIAT, E.V.; NAIR, R.V. and VARGHESE, P.T. 1979. Response of high yielding coconut genotypes to fertilizer levels under rainfed conditions. In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliatt and others. p.87-100 (CPCRI, Kasaragod, Kerala).

A field experiment was conducted to determine the NPK fertilizer requirement of three coconut genotypes viz., West Coast Tall progenies of high yielders, Dwarf x Tall and Tall x Dwarf and to evaluate their performance under three levels of fertilizer application. The genotypes did not differ in their response to 'no fertiliser' hybrid outyielded the Tall and the reciprocal hybrid T x D. Contrary to expectation, the response of the Tall was found linear.

112. NELLIAT, E.V. and PADMAJA, P.K. 1979. Irrigation requirement of coconut and response to different levels of fertilizer under irrigated conditions during the early bearing stage. In:

Symposium Plantation Crops, 1st, RRII, Kottayam Mar. 20-23, 1978. Proceedings of PLACROSYM 1. Edited by E.V. Nelliatt and others. p.186-199. (CPCRI, Kasaragod, Kerala).

An investigation to determine the irrigation requirements of coconut and the optimum fertilizer dose under irrigated condition was carried out. The growth characters and yield performance on palms in the early bearing stage showed that depth of irrigation water, had negligible effect. Based on the performance during early bearing stage, the irrigation requirement of coconut found to be 660-680 mm/dry season, irrigating at IW/CPE ratio of 0.75.

✓ 113. PARTHASARATHY, M. 1982. Coconut response to drip irrigation. *Indian Cocon. J.* 13(6):3-6. (UNIDO Expert, Sastrinagar, Madras, T.N.)

The concept of drip Irrigation relatively new to India, has been a well tested technology on a variety of crops all over the world for more than a decade. The major difference between flood and furrow irrigation, or for that matter, even the sprinkler irrigation and drip system, is in the slow and sustained release of water at the root zone. This brings about remarkable changes to the plant and its roots besides the substantial savings in water. Crop response to this system under diverse conditions, has been uniformly excellent with improvements in quality, quantity and maturity period of yields. The technology is quite complicated and involved at the initial system design and installation stage but very simple to operate and maintain, once it is properly installed. Assured and quite predictable good yields using minimal water and nutrients justify its adoption for almost all crops under all conditions.

114. PARTHASARATHY, M. 1985. Drip irrigating coconuts. *Indian Cocon. J.* 15(7):8-11. (UNIDO Expert, Sastrinagar, Madras, T.N.).

The response to drip irrigation was reported to be significant in new as well as old plantations. In 10 year old plantations, the response was most spectacular, yielding 120–150 nuts per palm per annum. Cost benefits of drip irrigation are also given in the paper.

115. PATIL, P.B. and GEORGE, T.G. 1980. Home gardening in coconut holdings. *Indian Cocon. J.* 10(10):1–4. (CPCRI (RS), Kayangulam, Kerala).

The utilisation of home gardens for small coconut plantations is discussed. A plan is drawn in which the proper arrangement of home gardens with coconut and other plants illustrated.

116. PETER, S.D. and SRINIVASAN, K. 1979. Response of selected and unselected seedlings of East Coast Tall variety of coconut to manuring, irrigation and cultural practice. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar., 20–23, 1978. Proceedings of PLACROSYM I.* Edited by E.V. Nelliath and others. p.207–212. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Ten year results of an experiment started in 1967 to study the difference in vigour and productivity of 'selected' and 'unselected' seedlings grown under intensive management are presented in the paper. Among the practices, manuring alone or in combination with irrigation and/or ploughing from the seedling stage had significant effect on the growth characters and yield components and yield.

117. RAJAGOPALAN, A.; NAIR, R.R. and RAO, G.S.L.H.V. PRASADA. 1988. Water requirement of young TxGB coconut hybrids. *In: National Seminar on Agrometeorology of Plantation Crops, RARS, Pilicode, KAU, Mar. 12–13, 1987. Proceedings of seminar.* p.27–29. (RARS, KAU, Pilicode, Kerala).

Irrigation of IW/CPE ratio of 1.00 sig-

nificantly increased the seedlings height, collar girth and total number of leaves. It also, recorded maximum consumptive use (794 mm) followed by irrigation at IW/CPE ratio of 0.75 (716 mm) and 0.50 (643.4 mm). The ratio between crop evapotranspiration and open pan evaporation was 0.75.

118. RAJAGOPALAN, A.; RAVEENDRAN NAIR, R.; RAO, G.S.L.H.V. PRASADA and NAMBIAR, I.P.S. 1988. Influence of irrigation and fertilizer levels on the flowering behaviour of TxGB coconut hybrids. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23–26, 1988. Abstracts of papers.* p. 38. (RARS, KAU, Pilicode, Kerala).

The effect of three irrigation levels at IW/CPE ratios of 0.5, 0.75 and 1.00 and four fertilizer levels, viz., (1) 0.5:0.5:1.5, (2) 0.5:0.5:2.0, (3) 0.5:1.0:2.0 and (4) 1.0:0.5:2.0 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O per palm per year on the percentage of flowering in West Coast Tall x Gangabondam hybrids was studied during 1984–1987. Irrigation at IW/CPE ratio of 1.00 and fertilizer level of 0.5:0.5:1.5 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O per palm per year were significantly superior to other treatments. Based on the early flowering nature of TxGB progenies, the male and female parent palms for making future crosses have been identified.

119. RAJAMONY, L.; KANNAN, K. and BALAKRISHNAN, P.C. 1983. Comparative performance of coconut hybrids in the laterite soil under rainfed conditions; a preliminary study. *Indian Cocon. J.* 14(8):7–11. (Coconut Res. Station, KAU, Trichur, Kerala).

Coconut hybrids have been reported to bear earlier and yield more number of nuts and higher copra than the local cultivar, West Coast Tall. However considerable variations occur in the progenies involving different parental combinations. Hybrids show difference

in their performance according to locations. The differential performance of various hybrids in different locations suggest the need for evolving high yielding hybrids suited to specific locations.

120. RAMAKRISHNAN NAYAR, T.V. and SAHASRANAMAN, K.N. 1978. Performance of four fodder crops in coconut garden under rainfed and irrigated conditions. In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p. 425-430. (CPCRI (RS), Kayangulam, Kerala).

A field experiment was conducted during 1975-'77 to compare the performance of four fodder crops—two genotypes of hybrid Napier, viz., Pusa Giant and NB 21 and Guinea grass (Makuenii) and legume *Stylosanthes gracilis* in coconut gardens under rainfed as well as under irrigated conditions. The graminaceous fodders Pusa Giant, NB 21 and Guinea grass were on par in herbage yield but gave significantly higher yield than the legume *Stylosanthes*, both under rainfed and irrigated conditions. The increase in yield of green fodder due to irrigation was highest in the case of NB 21 (55%) followed by Pusa Giant (44%). Under rainfed conditions and during dry seasons highest green fodder yields were obtained from Guinea grass.

121. RAMANATHAN, T. 1982. Techniques to increase copra yield in coconut. *TNAU News Letter* 12(3):4 (School of Genetics, TNAU, Coimbatore, T.N.).

Manurial schedule with 50 kg of compost plus NPK at 560:320:1200 g/palm, irrigation at 10 days interval and intercultural operation of ploughing twice in July–August and December–January were adopted singly and in combination for adult palms of East Coast Tall Variety. There was an increase of 38 kg of copra due to interculture and 48 kg/ha due to irrigation alone. Manuring alone increased

the copra yield by 743 kg/ha. Manuring followed by irrigation resulted in an increase of 1234 kg/ha. Combination of manuring, irrigation and intercultural operation gave significant increase of 1460 kg/ha of copra compared to control.

122. RAMANATHAN, T. 1984. Management practices for increasing coconut production in Tamil Nadu. *Indian Fmg* 34(2):17–20. (School of Genetics, TNAU, Coimbatore, T.N.).

VHC 1 Coconut hybrid (East Coast Tall x Malaysian Green Dwarf) which has established its superiority over East Coast Tall, in nut, copra and oil yield was recommended. Crop management including manuring, irrigation and interculture and their influence in increasing the yield were highlighted. The synergistic effect of raising intercrop of banana in increasing coconut yield has been brought out.

123. RAMANATHAN, T.; BALASUBRAMANIAN, R. and VIJAYARAGHAVAN, H. 1984. Herbicides and interculture; their effect and impact on the yield of coconut. In: Symposium on Plantation Crops, 6th, RRII, Kottayam, Dec. 16–20, 1984. Proceedings of PLACROSYM VI. Edited by M.R. Sethuraj and others. p. 273–243. (School of Genetics, TNAU, Coimbatore, T.N.).

A trial was conducted to study the efficacy and economics of certain herbicides and ploughing practices on weed growth and nut yield in coconut. The herbicides were effective only in reducing the weed growth as indicated by the lower fresh weight of weeds in the herbicides treated plots. The suppression in the growth of weeds by herbicides did not improve the nut yield. On the other hand, ploughing the entire area enhanced the yield of nuts by as much as 21 per cent over control.

124. RAMANATHAN, T.; BALASUBRAMANIAN, R. and VIJAYARAGHAVAN, H. 1984. Moisture

conservation through mulches in coconut. In: Symposium on Plantation Crops, 6th, RRIL, Kottayam, Dec. 16-20, 1984. Proceedings of PLACROSYM VI. Edited by M.R. Sethuraj and others. p.375-379. (School of Genetics, TNAU, Coimbatore, T.N.).

Different mulching materials which are locally available such as coconut husks, fodder trash, coconut leaves and palmyrah leaves were tried in a rainfed adult bearing coconut garden, in order to find out a suitable mulching material. Mulching with coconut husks in a 2m. radius around the base of palms increased the yield by 49.6%, followed by burying coconut husks and leaves in trenches between the rows of palms which increased the yield by 44.6% over control. The coconut husks and leaves conserved moisture very effectively as evidenced by the highest moisture percent recorded in the soil.

125. RAMANATHAN, T.; PETER, S.D.; and VENKATESWARAN, A.N. 1982. Effect of agronomical inputs on the growth and yield of coconut. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.437-441. (School of Genetics, TNAU, Coimbatore, T.N.).

Results of a study carried out to investigate the effect of agronomic inputs, manuring, irrigation and cultural operations, on the morphological characters and yield of coconuts in alluvial soils of Cauvery delta of peninsular India are reported. The treatment effects on contributions were additive on morphological characters and synergistic on yield. There are indications to show that the selection of seedlings alone for planting is not effective.

126. RAO, G.S.L.H.V. PRASADA. 1982. Rainfall and coconut yield in the Pilicode region, North Kerala. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, 15-18 Dec. 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p. 388-393. (RARS, KAU,

Pilicode, Kerala).

The number of dry spells in the rainy season was low and appeared to have no effect on coconut yield. However, it appears that the continuous dry spell for six months with high moisture deficit during the summer and high water surplus during July decreased the coconut yielding in the subsequent year. The yield in a particular year is above normal if the previous year's annual rainfall was below 3100 mm, while below normal if it was above 4275 mm.

127. RAO, G.S.L.H.V. PRASADA. 1985. Drought and coconut palm. *Indian Cocon. J.* 15(12):3-6. (RARS, KAU, Pilicode, Kerala).

A formula is presented for determining weekly aridity indices for the year 1982-83. Drought symptom (drooping of lower leaves) were noted when the aridity index was 8.35%. Although the water deficit started in November the visual symptoms did not appear until late January. At 90% aridity index, drying of dropped leaves and button shedding occurred.

128. RAO, G.S.L.H.V. PRASADA. 1986. Effect of drought on coconut production. *Indian Cocon. J.* 17(8):11-12. (RARS, KAU, Pilicode, Kerala).

The effect of drought on annual nut yield was seen only in the subsequent year under good management conditions. The effect of drought on monthly nut yield was seen in the eighth month with the maximum reduction in the thirteenth month after the drought period was over.

129. RAO, G.S.L.H.V. PRASADA. 1988. Agrometeorology of coconut. In: Six decades of research. Edited by M. Aravindakshan and others. Trichur: Kerala Agricultural University. p.81-93. (RARS, KAU, Pilicode, Kerala).

Work done in the Kerala Agricultural University on Agrometeorological aspects was reported.

130. RAO, G.S.L.H.V. PRASADA. 1988. Performance of TxD coconut hybrids in drought years under irrigated conditions in red sandy loam. In National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.20 (RARS, KAU, Pilicode, Kerala).

The per palm annual nut yield of TxD was higher than the West Coast Tall even in drought years during which prolonged dry spells occurred in the summer months. Both the varieties exhibited no alternative bearing character if the annual nut yield of the entire block was taken into consideration. The summer rains from March to May which maintain the microclimate conducive in addition to the better soil moisture profile are essential for obtaining good yield in the following year even under irrigated conditions.

131. RAO, G.S.L.H.V. PRASADA; BALAKRISHNAN, P.C. and NAIR, R.R. 1986. Preliminary studies on performance of coconut hybrids during drought years under rainfed conditions. In: Workshop on Impact of Drought on Plantation Crops, CPCRI, Kasaragod, May 26-27, 1986. Extended summaries. p.13-15. (RARS, KAU, Pilicode, Kerala).

The adverse effect of drought on annual nut yield is less pronounced in low yielders. The total number of leaves drooped due to soil moisture stress are positively correlated. The performance of hybrids viz., TxSST, TxTBL and TxGB was relatively better during the drought year.

132. RAO, G.S.L.H.V. PRASADA and NAIR, R.R. 1988. Influence of soil texture on the thermal regime of coconut root zone. In: National Seminar on Agrometeorology of Plantation Crops, RARS, KAU, Pilicode, Mar. 12-13, 1987. Proceedings of the seminar. p.57-62. (RARS, KAU, Pilicode, Kerala).

The mean annual soil temperature in the

coconut root zone was higher (30.1-32.7°C) in sandy loam than in loam (27.9-30.6°C). Though the root zone temperature was high during the summer in both the soils, the magnitude of difference between the two soils was in high (1.9-5.9°C) in the post monsoon season and low (0.9-2.0°C) in the South West monsoon. A marked difference in the thermal regime of coconut root zone was seen during the summer months of 1983 (drought year) and 1984 (Normal year) in the same soil. Under mulched and exposed conditions in the loam soil, the difference in coconut root zone temperature was about 1.0 in summer and 0.3 in the South West monsoon. The coconut root zone temperature in the loam soil was 28.6°C under coconut husk mulch and 29.2°C under no mulch at both 40 and 60 cm depths.

133. RAO, G.S.L.H.V. PRASADA and NAIR, R.R. 1988. Influence of weather on nut development in coconut. *J. Plantn Crops* 16(Suppl.): 469-473. (RARS, KAU, Pilicode, Kerala).

The maximum copra content was noticed in summer in all the three hybrids. The second phase of nut development in all the hybrids was seen influenced by the heat units and other weather elements had no significant influence on Phase II. For estimating the nut size, simple quadratic regressions were worked out using the heat units during the second phase of nut development.

134. RAO, G.S.L.H.V. PRASADA and NAIR, R.R. 1988. Vertical profile of air temperature and vapour pressure in coconut gardens and open space. In: National Seminar on Agrometeorology of Plantation Crops, RARS, Pilicode, Mar. 12-13, 1987. Proceedings of the seminar. p.63-69. (RARS, KAU, Pilicode, Kerala).

Air temperature decreased with height in the open whereas no definite pattern was seen inside the coconut garden due to its canopy structure. The difference in temperature between the open and inside the coconut garden

was high (1.0°C) at 30 cm above the ground level and low (0.1°C) at 7 m height. Higher amplitudes in air temperature were noticed at the lower levels when compared to the canopy level inside the coconut garden.

135. RAO, G.S.L.H.V. PRASADA; NAIR, R.R. and RAZAK, M.P. ABDUL. 1984. Influence of weather on coconut yield. In: Symposium on Plantation Crops, 6th, RRIL, Kottayam, Dec. 16-20, 1984. Proceedings of PLACROSYM VI. Edited by M.R. Sethuraj and others. p.381-389. (RARS, KAU, Pilicode, Kerala).

The absence of post and pre-monsoon showers (October to April) and the high rainfall during the rainy season (June to August) adversely affected the subsequent years nut yield of coconut. The mean cumulative bright sunshine hours from the primordium inflorescence to the initiation of spikes (28 to 44 months before harvest) favourably influenced the nut yield of coconut.

136. REDDY, K. VENKATA SUBBA and REDDY, P. SETHA. 1981. Method of planting seed coconuts. *Andhra Agric. J.* 28(1-2):93. (Coconut Res. Station, APAU, Ambajipet, A. P.).

Results of a trial on the efficacy of different sowing methods for coconut seednuts have been discussed.

137. RETHINAM, P. 1988. Management of coconut palms. In National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.29-30. (CPCRI, Kasaragod, Kerala).

Coconut shows good response to the management conditions right from the planting. Addition of organics such as coir dust, coconut sheddings, forest leaves and cattle manure along with recommended dose of NPK improved the initial growth and reduced the mortality of coconut seedlings from 50% to

17% in coastal sandy soil. The response of West Coast Tall coconut to different management practices was found to vary widely. A four fold increase by cultivation and manuring and a six fold increase by manuring and irrigation have been achieved. Nutrient and irrigation management play a vital role in increasing the production and productivity of coconut. An young palm manured and irrigated regularly comes to flowering within 3½ years in case of hybrid and 4 years in case of tall. A neglected old coconut garden rejuvenated with fertilizer management with double dose in the first year and single dose subsequently could increase the nut yield by 265% within four years.

Phosphorous management in palms indicates that skipping of phosphorus for five to six years is possible if available P level is 60 ppm or above. Evaluation of different hybrids and talls have indicated that COD x WCT hybrids can exploit the native fertility of the soil and also applied nutrients than WCT.

138. SALAM, M. ABDUL and MAMMEN, M.K. 1990. Soil and climate based irrigation scheduling for adult coconut. *Indian Cocon. J.* 21(3):1-5. (KAU, Sub-Centre, Kottarakkara, Kerala).

An attempt has been made to develop a soil and climate based, irrigation schedule for adult coconut. The study revealed that coconut is to be irrigated during January to April in South Kerala. In Entisols (Coastal alluvium) coconut is to be irrigated in the basins in an area 12 m<sup>2</sup> around the palm, with 360 l of water per palm at an interval of 2-3 days during January, 2 days during February-March and 6 days during April. In the Alfisols (red loam) 540 l of water may be supplied per palm at an interval of 4 days during January, 3 days during February, 3-4 days during March and 9-10 days during April. In Oxisols (laterites) 720 l of water may be supplied per palm at

an interval of 5-6 days during January 4-5 days during February-March and 12-13 during April.

139. SASEENDRAN, S.A. and JAYAKUMAR, M. 1988. Consumptive use and irrigation requirement of coconut plantations in Kerala. *J. Plantn Crops* 16(2):119-125. (CWRDM, Calicut, Kerala).

An attempt was made to compute the water requirements of coconut plantations in different months of the year, using different climatological methods. Efforts were also made to evaluate the mean effective rainfall in Kerala under coconut-based land use, using mean rainfall and water requirement data. The mean annual water requirement of coconut plantations was 1126 mm (37 l/palm daily for a basin area of 12 m<sup>2</sup>) and the mean annual irrigation requirement was 338 mm (4656 l/palm for a basin area of 12 m<sup>2</sup>), spread over the non-monsoon months of January, February, March, April, May, November and December.

140. SEN, N.L.; KIKKANI, K.P.; UGHREJA, P.P. and VALIA, R.Z. 1983. Root zone studies in coconut (*Cocos nucifera* L.) under Gujarat conditions. *Indian Cocon. J.* 14(1):6-8. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

Vertical (0-180 cm) and horizontal (0-300 cm) root distributions were determined in 25, 50, and 75-year-old palms growing on clay loam soil.

141. SHANTAMALLAIAH N.R.; KUMAR C.; MURUGENDRA and MANOHAR, R. KRISHNA. 1978. Effect of coir dust mulching on water requirement and performance of coconut seedlings in the nursery. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I.* Edited by E.V. Nelliath and others. p.261-266. (RCRS, UAS, Arsikere, Karnataka).

Results of an experiment carried out to

investigate the beneficial effects of coir dust mulching under varying soil moisture regimes to fix optimum conditions for raising coconut seedlings are reported in the paper.

142. SHANTHAMALLAIAH, N.R.; VENKATESHA GOWDA, T.N.; KRISHNA MANOHAR, R. and BALAKRISHNA, P. 1982. Effect of spacing and fertilizer on growth and yield of Arsikere tall coconut cultivar in maidan tract of Karnataka. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, 15-18 Dec. 1982. Proceedings of PLACROSYM V.* Edited by K.V. Ahmed Bavappa and others. p.442-447.

In the maidan tract of Karnataka, closer spacing (7.3 x 7.3 m) gave significantly higher yield of nuts per hectare over wider spacing (9.7 x 9.7 m) after 3 and 4 years in black and red soils respectively. The five year average showed that the yield increase per hectare due to closer planting was 28 per cent in red soil and 3 per cent in black soil. The application of fertilizers did not increase the yield significantly red soil, whereas it increased the yield significantly in black soil in 4 out of 5 years. Generally, closer planting and fertilizer application increased the yield of Arsikere tall coconut.

143. SINGH, SHYAM and GANGWAR, B. 1989. Integrated farming systems for the Islands. *Indian Fmg* 38(11): 21-24. (CARI, Port Blair, A & N Islands).

The existing farming systems of the Andaman and Nicobar Islands are described in detail. Viz., cultivation of rice, other field crops and vegetables, Animal husbandry Fisheries and a number of integrated farming systems are being tried at CARI, at Sipighat.

144. SIVANAPPAN, R.K. and KOTTISWARAN, S.V. 1985. Drip irrigation for coconuts in India. *In: Drip/trickle irrigation in action; v.1: 198-203.* (Water Technology Centre, TNAU, Coimbatore, T.N.).

seedlings at 60 cm depth.

154. VIJAYARAGHAVAN, H. and RAMACHANDRAN, T.K. 1989. Effect of *in situ* cultivation and incorporation of green manure crops on the yield of coconut. *Cocos* 7:26-29. (RARS, TNAU, Veppankulam, T.N.).

A field experiment was carried out in Thanjavur district, Tamil Nadu, India with six green manure crops to study their ability to grow and establish in the coconut basin and to evaluate their effect on yield. Among the crops tested, *Desmodium tortuosum* was found to be the best producing 12.8 kg of green leaf matter per basin followed by cowpea (*Vigna unguiculata*) and sunhemp (*Crotalaria juncea*). The dry matter production was also found to be superior in *Desmodium* compared to others. Incorporation of *Desmodium* added 250 g of N/Crop/basin which was the highest. *In situ* cultivation of *Desmodium* and sunhemp significantly increased the nut yield of coconut.

✓ 155. VIJAYARAGHAVAN, H. and RAMACHANDRAN, T.K. 1989. Seasonal variation in barren nut production in TallxDwarf hybrids of coconut. *Indian Cocon. J.* 19(9):7-11. (RARS, TNAU, Veppankulam, T.N.).

The seasonal variation in yield of nuts and barren nuts in ECT and Tall x Dwarf hybrids (T x D) was studied with particular reference to the rainfall and temperature on barren nut production.

✓ 156. VIJAYARAGHAVAN, H.; RAVEENDRAN, T.S. and RAMANATHAN, T. 1988. Influence of weather factors on the yield of rainfed coconut (*Cocos nucifera* L.). *Indian Cocon. J.* 18(9): 7-10. (RARS, TNAU, Veppankulam, T.N.).

To assess the influence of weather factors such as rainfall and temperature on rainfed coconut, studies were conducted. Moderate levels of rainfall and relatively higher minimum temperature (around 20°C) were conducive for higher yield.

157. YUSUF, MOHAMED and GOPALASUNDARAM, P. 1988. Management of hybrid coconut palms. *In* : Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-28, 1988. Abstract of papers. p. 33-34. (CPCRI, Kasaragod, Kerala).

Coconut hybrids, namely Chandrashankara (CODxWCT), and Chandralaksha (LOxCOD) from CPCRI, Kasaragod, Lakshaganga (LOxGB) and Anandaganga (AOxGB) from the Kerala Agricultural University and VHC-1 (ECTxCGD) and VHC-2 (ECTxMYD) from the Tamil Nadu Agricultural University have been released for cultivation. Hybrids, Chandralaksha, Lakshaganga and Anandaganga were found tolerant to drought.

Under rainfed conditions of Kasaragod with the fertilizer level of 500 g N+500 g P<sub>2</sub>O<sub>5</sub>+1000 g K<sub>2</sub>O/palm/year, hybrid Chandrashankara produced 85 nuts/palm/year as against 70 nuts and 59 nuts/palm/year in hybrid WCTxCOD and WCT respectively. With 20 mm irrigation through perfo-sprinkler, at weekly interval, the yields of these hybrids were 181 and 161 nuts/palm/year. Hybrid Chandrashankara showed higher efficiency in utilizing native fertility and attained early bearing than hybrid WCTxCOD and WCT.

## 4. DISEASES

### 4.1 Root (Wilt) Disease

158. ABRAHAM, JOSE, RAWTHER, T.S.S.; JACOB, P.M. and CECIL S. ROBERT. 1987. Trend in yield of root (wilt) affected coconut palms (*Cocos nucifera* Linn.) *J. Plantn Crops* 15: 38-41. (CPCRI (RS), Kayangulam, Kerala).

Correlation and regression studies were carried out on yield and disease index of root (wilt) affected coconut palms. The significant negative correlations obtained between yield and disease index revealed the debilitating impact of the disease on the yield. Regression equations fitted on data collected from 500 palms aged above 30 years in the farmer's field showed an average reduction of 0.5 nuts per index while it was 1.3 nuts per index for the younger palms (aged below 13 years) under the well managed farm conditions. This indicates that the impact of disease is more in the case of palms which contract disease during the early years of bearing. However, the average yield of palms under the well managed conditions were consistently high upto the index of 50 showing the effect of good management on maintaining the yield.

159. ALICE, K.J.; KARUNAKARAN, P. and SAMRAJ, J. 1980. A comparative study of the rhizosphere microflora of coconut palms from diseased and healthy areas with reference to root (wilt). *Indian Cocon. J.* 11(2): 1-4. (Dept. of Plant Pathology, College of Agric., KAU, Trivandrum, Kerala).

Palms affected by root infecting pathogens support a higher rhizosphere microbial pathogens than healthy ones. It was noticed that the total microbial population in rhizosphere was much higher.

160. BAVAPPA, K.V.A. 1983. Root (wilt) disease of coconuts where & whither. *Indian Cocon. J.* 13(9): 9-11. (CPCRI, Kasaragod, Kerala).

The root (wilt) disease of coconut palm which has affected more than 30% of 7,50,000 ha of coconut plantations in Kerala causes an estimated annual loss of 340 million nuts. Though the exact cause for the disease is unknown experimental results reveal that improvement of soil physical conditions and adoption of mixed cropping/mixed farming system, use of better planting materials and adoption of package of practices give higher yield in spite of the diseased conditions. The need for the operation of large scale field programme involving plant quarantine measures, regular removal of diseased palms, re-planting with quality seedlings application of organic manures and practice of mixed farming systems etc. with a view to overcome the disease is stressed.

161. BAVAPPA, K.V.A.; JAYASANKAR, N.P.; RADHA, K. and RETHINAM, P. 1986. Coconut root (wilt) disease, present status of research and management. Technical Bulletin no.14. 10p. (CPCRI, Kasaragod, Kerala).

This publication gives an up-to-date information on status of research on root (wilt) disease and measures for containing the disease to its present geographical limits and managing the disease in highly diseased contiguous areas. Future lines of research are also outlined.

162. BIDDAPPA, C.C. 1984. Distribution pattern of heavy metals in coconut crown under root (wilt) diseased and healthy conditions *J. Plantn. Crops* 12(2): 133-139. (CPCRI, Kasaragod, Kerala).

The heavy metal contents in the coconut crown were evaluated both in root (wilt) diseased and healthy coconut palms. The studies indicated that the concentration of Cr, Pb, Ba, Bi, Ga, Sr and Li were significantly higher in

With the advent of drip irrigation, water can be conserved by about 60 percent and thus more area can be irrigated with same amount of water. With many advantage like water conservation, economic use of labour, use of saline water, weed control etc. the drip irrigation was found to be suitable for coconut cultivation in India.

145. SUDHAKARA, K.; KANNAN, K. and NAMBIAR, I.P.S. 1989. Effect of defoliation on the productivity of coconut palm (*Cocos nucifera* L.) cv. WCT. *J. Plantn Crops* 16(Suppl.):457-461. (RARS, KAU, Pilicode, Kerala).

Trials were carried out with 55-year-old cv. WCT palms to study the effects of removing the 1, 2 or 3 oldest leaves in successive or alternate months in the summer. A total of 0 to 10 leaves was removed in the six different treatments. Leaf removal had no adverse effect on female flower production, setting percentage or nut yield. The highest income (Rs. 1109/year from the sale of leaves was obtained when 2 leaves were removed every month.

146. THOMAS, D. 1978. Pastures and livestock under tree crops in the humid tropics. *Trop. Agric.* 55(1):39-44. (School of Agriculture, Edinburgh Univ., Edinburgh, U.K.).

The problems of integrating pastures, livestock and three crops are discussed with special reference to rubber, oil palm and coconut. The greatest potential for integration exists with mature coconut plantations where tall unimproved strains of coconut are grown. A wide range of pasture species was established under coconut, but there is a paucity of quantitative information on comparative performance and the effects of grazing management.

147. UTHAIAH, B.C. and LINGAIAH, H.B. 1989. Studies on the effect of mulches on coconut seedling establishment. *Indian Cocon. J.* 20(4):

7-8. (Regional Res. Station, Brahmavar, Karnataka).

One-year-old West Coast Tall seedlings were planted in the field at 9 x 9m in August and in November. The plants were mulched with several materials. The effects were assessed in June of the following year. The highest plant survival (86.7%) was obtained with coir pith laid at 10 cm thickness. Survival in the nonmulched control was 53% and it ranged from 50 to 83.3% in the other treatments.

148. VARADAN, K.M. and MADHAVA CHANDRAN, K. 1988. Irrigation requirement of coconut under drip method. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.38.* (CWRDM, Calicut, Kerala).

There were five treatments viz., drip irrigation at 15, 30 and 45 l/day/palm, basin irrigation at 600 l/week/palm and control (unirrigated), with four replications. Observations on yield were recorded for the period 1985-'87. The results showed that treatment effects were significantly different from control at 5% level. Yield of nuts for drip method at 30 to 45 l/day/palm was on par with basin irrigation at 600 l/week/palm.

149. VARADAN, K.M. and RAO, A.S. 1983. Effect of mulch on soil temperature in humid tropical latosols under coconuts (*Cocos nucifera* Linn.) and banana (*Musa paradisiaca*). *Agric. Met.* 28(4):375-386 (CWRDM, Calicut 673 571, Kerala).

Soil temperatures (measured twice daily) 5-10 cm below the surface were 2-6°C lower under mulched coconut palms than under unmulched palms, and the difference under plantains was 1-6°C. Under both crops mulching confined the diurnal maximum to between 30°C and 33°C, while with no mulch the maximum rose to 40°C. The surface soil

temperature decreased from an average 38°C to 27°C with the onset of the rains.

150. VARADAN, K.M.; RAO, A.S. and VAMADEVAN, V.K. 1987. Effect of soil moisture deficit on crop evaporation of coconut. *J. Indian Soc. Soil Sci.* 35:597-602. (CWRDM, Calicut, Kerala).

The reduced crop evaporation (RCE) of coconut at different seasons was quantified based on soil moisture depletion and potential evaporation. The RCE values range from 0 to 0.5 mmd<sup>-1</sup> during the wet period (June-September), 0.1 to 2.3 mmd<sup>-1</sup> during the rainfall transition period (October-November) and 1.1 to 6.8 mmd<sup>-1</sup> during the dry period (December-May). A relationship between RCE and soil moisture index (SMI-0.75) has been established. The soil and atmospheric water potentials in different seasons have been depicted in relation to reduced crop evaporation. The RCE values have to be considered for quantification of water requirement of coconut.

151. VARADAN, K.M. and REGHUNATH, B. 1983. Soil water flux in humid tropical latosols under coconut (*Cocos nucifera* L.) *Agric. Met.* 30(2):99-110. (CWRDM, Calicut, Kerala).

Soil moisture fluctuation in humid tropical latosols under coconut is described and the actual field observations were compared with those computed from meteorological variables.

The field observations of soil moisture flux agree closely with computed values for wet periods of the year, while they differ significantly for dry periods. Modification is suggested for the computation of soil moisture storage by climatic approach to minimise the difference between observed and computed values. The physical properties of the soil profile and hydrological site characteristics of the observational area are discussed in relation to soil moisture flux. The observed soil moisture fluctuation varies from 17.0 to 25.0 cm and

6.8 cm to 12.8 cm per 75 cm depth profile for wet and dry periods, respectively.

A soil moisture index has been proposed as a ratio of actual to potential storage to demarcate the period falling below permanent wilting point.

152. VARGHESE, ABRAHAM and KUNJU, MOHAMED. 1987. Influence of weather parameters on the yield of coconut in the back water areas of Kuttanad. *In: Symposium on Agrometeorology of Plantation Crops, RARS, Pilicode, Mar. 12-13, 1987. Proceedings of the symposium.* p.133-137. (Rice Res. Station, KAU, Kayangulam, Kerala).

The relationship between weather parameters and nut yield of coconut was explained based on the correlations. An increase in the maximum temperature adversely affected the coconut yield during the third year; low humidity during pre-monsoon was favourable for good nut yield in the same year; an increase in total rainfall was less beneficial to the second year yield, but increased yield in the same and third years.

153. VIJAYAN, K.P.; KRISHNASWAMY, V. and LOUIS, I. HENRY. 1979. Effect of planting depths on the growth, nut yield and the ability to withstand cyclone of the East Coast Tall variety of coconut. *Indian Cocon. J.* 9(9):6-9. (Coconut Res. Centre, TNAU, Veppankulam, T.N.).

Coconut palms planted at 60 and 90 cm depths were found to withstand the effect of cyclone. At 60 cm depth, significantly more number of leaves in the crown (8.5%) were recorded than in the surface planting treatment. Though statistically not significant, more values were observed for deep planting treatments in regard to the height, number of leaves produced, female flower production, setting percentage, copra yield per palm and the weight of husked nuts. Under East Coast conditions, it is advisable to plant the coconut

the diseased palms. The localisation and translocation of heavy metals in different leaf positions are primarily dependent on nature of the metalion itself.

163. BIDDAPPA, C.C. 1985. Identification of heavy metal deposit in the cabbage tissues of diseased coconut palms (*Cocos nucifera* L.) by using electron microprobe x-ray micro-analyser. *Curr. Sci.* 54(14): 679-682. (CPCRI, Kasaragod, Kerala).

The depositions of Cr, Ti, Cu, Pb, Bi and Ga in the cabbage tissue of root(wilt) diseased coconut palms were investigated by employing scanning electron x-ray microprobe analyser. The x-ray oscillogram and back scattered electron image of specimen indicated the high deposition of Cr, Ti, Cu, Pb, Bi and Ga in the cabbage of diseased palms. They were absent in the healthy palms. This was also confirmed in chemical analysis of tissue and soil samples under identical conditions.

164. BIDDAPPA, C.C. and CECIL, S. ROBERT. 1984. Electron microprobe and x-ray microanalysis of diseased coconut (*Cocos nucifera*) roots *Pl. Soil* 79(3): 445-447. (CPCRI, Kasaragd, Kerala).

Electron microprobe x-ray analysis of root (wilt) diseased and healthy coconut roots indicated high concentration of Al, Mn, Cu and Co localised in diseased roots, in comparison with healthy roots. Chemical analysis of leaf tissue samples showed higher concentrations of these metals in healthy than in diseased palms. The results indicate that impeded translocation of these metals from root to leaf tissues is associated with root (wilt) disease.

165. CECIL, S. ROBERT and KAMALAKSHY AMMA, P.G. 1991. Soils and nutrition. *In*: Coconut root (wilt) disease. Edited by M.K. Nair and others Kasaragod: CPCRI. Monograph Series no. 3. p.45-52. (CPCRI, Kasaragod, Kerala).

An extensive review covering all the aspects on the possible role of nutrients and micronutrients in coconut root (wilt) disease. Nutritional survey on the soil status, leaf nutrient levels in relation to disease incidence, NPK trials and role of Mg in disease management are also dealt with in detail.

166. CECIL, S. ROBERT., PILLAI, N.G.; KAMALAKSHY AMMA, P.G.; MATHEW, A.S. and NAMBIAR, P.T.N. 1982. Effect of major nutrients on the incidence of root (wilt) disease in coconut. *In*: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, 15-18 Dec. 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.474-481 (CPCRI(RS) Kayangulam, Kerala).

Studies on the effect of application of N, P, K, Ca and Mg from the time of planting in the main field at Kayangulam on the incidence and severity of root (wilt) disease in West Coast Tall palms indicated that, young palms are more susceptible to the disease at the onset of bearing. When young palms under good management contracted the disease before flowering, the onset of bearing was delayed by about 12 months. The frond production rate and the number of functioning leaves on the crown are considerably reduced in the diseased palms. Among the nutrients, Mg significantly increased the expression of both these characters thereby preventing the reduction in growth due to the disease. The disease caused about 60 per cent reduction in yield in the early bearing period. The mean yields of healthy and diseased palms at the 10th year of planting were 58.8 and 23.8 nuts/palm respectively. The disease caused about 12 per cent reduction in copra weight per nut while the reduction in oil content was not significant.

167. CECIL, S. ROBERT.; PILLAI, N.G.; MATHEW, A.S. and KAMALAKSHY AMMA, P.G. 1978. Effect of application of N, P, K, Ca and Mg on young

**West Coast Tall palms in the root (wilt) affected area.** In: Symposium on Plantation Crops, 1st, RRII, Kottayam, 20-23 Mar. 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. P.101-113. (CPCRI(RS) Kayangulam, Kerala).

The response to three levels of N, P and K and two levels of Ca and Mg by WCT palms from the seedlings stage was studied in a  $3^3 \times 2^2$  factorial split experiment conducted in loamy sand soil at CPCRI, Regional Station, Kayangulam since 1970. The fertiliser levels (adult) are: 500, 750, 1000g N; 300, 450, 600g  $P_2O_5$ ; 1000, 1500, 2000 g.  $K_2O$ ; 12.5 kg Ca  $(OH)_2$  and O, 500g MgO. The lime was applied broadcast uniformly and ploughed in, while the other fertilisers were applied only in the basins.

The effect of application of N was found significant in increasing the height of seedlings during the first year but not during the later years. The main effect of P was not found favourable on any of the characters. The effect of K was significant in increasing the girth at collar only during the third year. The response to Ca was significant in increasing the height of seedlings during the third year, but was highly significant on the number of functional leaves during the fourth year. The main effect of Mg was highly significant in increasing the girth at collar, height, number of leaves produced, number of functional leaves, early flowering and the cumulative yield of nuts harvested upto the seventh year. Irrespective of the treatments given, 19% of the palms had contracted the root (wilt) till December, 1977.

**168. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1976. Coconut diseases of uncertain etiology. Technical Bulletin no.1. Edited by R.D. Iyer. Kasaragod: CPCRI. 30p.

This publication includes surveys of the present state of knowledge concerning the

following 4 diseases: a) **Root (wilt) disease.** The history, symptoms, results of investigations (anatomy, etiology and soil chemistry), attempted control methods and proposed research programmes are outlined. b) **Thatipaka disease of Andhra Pradesh.** The symptoms and results of investigations concerning this malady are noted and compared with other complex coconut diseases. c) **Stem bleeding.** Details are given on the symptoms, etiology, results of investigations attempted on control and future research programmes. (d) **Tanjavur wilt.** The symptoms on the aerial parts, roots and flowers are described and the results of investigations presented.

**169. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1981. Review of research on coconut root (wilt) disease. Edited by K. Mathen and others. Kasaragod: CPCRI. 90p.

This publication deals with root (wilt) disease of coconut in Kerala State, published by a team of scientists of CPCRI. A brief account of the salient features of investigation on symptoms, etiology and control of root (wilt) disease has been given, while detailed descriptions given on origin, transmission, mycological investigations, microbiological aspects etc. by different personnel.

**170. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1985. Coconut root (wilt) disease, intensity, production loss and future strategy; a survey report. Kasaragod: CPCRI. 48p.

The report contains results of a survey on root (wilt) disease affected area in Kerala, conducted by CPCRI in collaboration with Department of Agriculture, Kerala, Directorate of Economics and Statistics, Centre for Development studies, Coconut Development Board, Kerala Agril. Univ. and Special. Agril. Developmental Unit, Govt. of Kerala. The disease occurs

in 8 out of 14 districts of Kerala, in intensities ranging from 1.52% in Trivandrum to 75.63% in Kottayam. The annual loss estimated due to the disease is 968 million nuts, in addition to loss in husk and copra yield and leaf number and quality. The total estimated money loss, on the basis of 1984 price is Rs.3,000 million.

**171. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1991. Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. 92p.

The entire data available on coconut root (wilt) disease have been collated in a manner assimilable to scientists, students and progressive farmers and presented in this monograph. Data are given under ten chapters as follows,

1) Origin, distribution and production loss 2) Symptomatology 3) Etiology 4) Diagnosis 5) Soils and nutrition 6) Physiology and biochemistry 7) Microbiology 8) Varietal resistance 9) Management 10) Leaf rot disease.

**172. CHEMPAKAM, B. and RAJAGOPAL, V.** 1986. Biochemical composition of vascular sap from the inflorescence of apparently healthy and root (wilt) diseased coconut palms. *J. Plantn Crops* 16 (Suppl.): 41-46. (CPCRI(RS), Kayangulam, Kerala).

Vascular sap was collected from the inflorescences of apparently healthy and root (wilt) diseased coconut palms under aseptic conditions. The PH of the sap ranged from 6.8 to 7.5. Osmotic concentration was lower in the sap from the root(wilt) affected palms (540-620 m moles/kg) while apparently healthy palms showed higher values (790-850m moles/kg). Direct analysis of the sap for sugars, proteins, free amino acids, lipids and sterols showed discernible difference between the healthy and diseased palms. The major amino acids, sugars and organic acids were detected in the sap based on chromatographic studies.

The possibility of utilising this data in preparing the media for culturing mycoplasma like organisms is discussed.

**173. CHOWDAPPA, P.; GOPINATHAN PILLAI, N.; GUNASEKARAN, M. and SOLOMON, J.J.** 1989. Distribution and retention of oxytetracycline hydrochloride injected into coconut palms affected by root(wilt) disease. *J. Plantn Crops* 17(2): 108-113. (CPCRI (RS), Kayangulam, Kerala).

Oxytetracycline HCl (OTC) was administered by pressure injector into the trunks of root (wilt) diseased coconut palms. Uptake, translocation and persistence of OTC in various parts of the palms were monitored by microbiological assay of buffer extracts of fresh tissue samples using *Bacillus cereus subsp. mycoides* (ATCC 6462). Presence of OTC in the foliage was detected within 24 h. after administration. The highest concentration was noticed after 5-6 days. Maximum detectable levels in the range of 3-11 Mg/g fresh weight were detected in the leaf No. 11. Lower concentrations in the range of 1.0-5 Mg/g fresh weight were detected in the leaf No.1,6 and 31 after a week of injection. With the onset of senescence, OTC gets redistributed from older leaves to the most actively transpiring leaves. Very little OTC activity was detected in roots, inflorescence, and spear leaf. Detectable levels of OTC was observed for more than 12 weeks in the foliage.

**174. DWIVEDI, R.S.; MATHEW, CHACKO.; RAY, P.K.; SUMATHYKUTTY AMMA, B. and NINAN, SUNNY.** 1977. Rapid biochemical test to detect root (wilt) disease of coconut. *Curr. Sci* 46(17): 611-612. (CPCRI(RS), Kayangulam, Kerala).

EDTA was used to extract biologically active substance/pigments present in the diseased palms. Leaf discs (0.5 cm diameter) cut from leaflets on both sides of the rachis of spindle and root tips (6cm long) were washed, blotted and extracted by steeping in 0.3 molar

EDTA (ph 6.8-7.0) for 5-7 min. The extracts were analysed colorimetrically with blue filter (400-450nm) and the colour of the extract identified according to A. Maerz and M. R. Paul method. The transmittance ratios of root/spindle were 1.86, 4.19 and 5.01 for healthy, early diseased and disease-advanced palms, respectively. These ratios were used as a criterion for the severity of the disease.

175. DWIVEDI, R.S.; MATHEW, CHACKO.; RAY, P.K.; SUMATHYKUTTY AMMA, B. and NINAN, SUNNY. 1979. Certain closely associated morphological symptoms of root (wilt) disease of coconut (*Cocos nucifera*). *Pl. Dis. Repr.* 63: 461-463. (CPCRI (RS), Kayangulam, Kerala).

Morphological symptoms of root (wilt) diseased coconut palms are manifested by softening and whitening of leaflets of the spear with necrotic spots followed by rotting. Interveinal yellowing in the leaves of the middle whorl was an additional symptom. These symptoms are held to be important in the early diagnosis of the disease in field-grown palms.

176. DWIVEDI, R.S.; POTTI V.P.; SUMATHYKUTTY AMMA, B.; GOVINDAN KUTTY, M.P.; SOLOMON, J.J. and JAYASANKAR, N.P. 1978. Investigations on vascular browning in the roots of root (wilt) diseased coconut (*Cocos nucifera* Linn.). *Curr. Sci.* 47(1): 31-32. (CPCRI (RS), Kayangulam, Kerala)

Root tips of healthy, apparently healthy or diseased coconut palms, cv. West Coast Tall, were collected and placed in water or antioxidant solution in the field, after which they were sectioned in the laboratory. Root sections studied immediately after keeping in water or antioxidant showed no browning of the vascular region after 5min. However, roots that had been kept in water showed browning of all tissues, whereas antioxidant prevented the development of browning.

177. DWIVEDI, R.S.; RAY, P.K. and NINAN,

SUNNY. 1979. Absorption, distribution and utilization of radioactive phosphorus in healthy and root (wilt) diseased coconut palms. *J. Nuclear Agric. & Biol.* 8(1): 33-35. (CPCRI(RS), Kayangulam, Kerala).

Radioactive  $\text{KH}_2^{32}\text{PO}_4$  was supplied to the leaves and roots of healthy and diseased coconut palms in the laboratory and the field and its absorption and accumulation was assessed at intervals up to 24 hrs and extending to 10 days, respectively. In laboratory studies more  $^{32}\text{P}$  accumulated in the leaves of healthy palms than in those of diseased palms during the first hour but thereafter this trend was reversed. In middle leaflets there was no consistent trend and in the top most leaflets  $^{32}\text{P}$  accumulation in the healthy palms was greater only for the first 14 min. In the field  $^{32}\text{P}$  was found in the spindle (topmost leaf) of 9.5m tall healthy and diseased palms 3h after treatment. In healthy palms  $^{32}\text{P}$  was more accumulated in the spear and first fully opened leaves than in diseased palms. In the middle and outer leaves however,  $^{32}\text{P}$  accumulation was higher in diseased palms throughout the experimental period. Data are also presented on the incorporation of  $^{32}\text{P}$  in different forms of inorganic P.

178. DWIVEDI, R.S.; SUMATHYKUTTY AMMA, B.; MATHEW, CHACKO. and RAY, P.K. 1980. Control of root (wilt) disease of coconut (*Cocos nucifera* Linn.) with micronutrients, phenolic compounds and ascorbic acid. *Pl. Dis. Repr.* 64(9): 843-844. (CPCRI(RS), Kayangulam, Kerala).

Certain phenolic compounds, micronutrients, and ascorbic acid markedly reduced root (wilt) disease symptoms on coconut. The improvement was most pronounced when all three treatments were applied in combination. Yield also increased significantly in all treatments except phenolic compounds.

179. GEORGE, MATHEW.; POTTY, V.P. and

**JAYASANKAR, N.P.** 1976. Association of *Enterobacter* with coconut root (wilt) disease. *Curr. Sci.* 45: 677-678. (CPCRI(RS), Kayangulam, Kerala).

*Enterobacter* sp. was found consistently associated with roots of root (wilt) affected coconut palms. The bacterium produced alcohol precipitable polysaccharide material, which showed reversible wilting of tomato seedlings *in vitro*.

**180. GEORGE, M.V.; THOMMEN, K.J. and SUKUMARAN, A.S.** 1979. Incidence of root (wilt) and leaf rot diseases and *Oryctes* infestation in Kerala. In Symposium on Plantation Crops, 2nd, Ootacamund, June. 26-29, 1979. Proceedings of the PLACROSYM II. Edited by C.S. Venkataram and others. p. 517-522. (CPCRI (RS), Kayangulam, Kerala).

The root (wilt) disease affected coconut areas in Kerala were surveyed adopting a multistage sampling procedure during 1971-'76 to estimate the percentage of palms affected by root (wilt) and leaf rot diseases and infested by *Oryctes*. The incidence of disease was maximum in Alleppey district (54%) followed by Kottayam (50%) and Idukki district (43%) and minimum in Trichur district (less than 5%) where the disease incidence was limited to the southern villages. The *Oryctes* infestation was as high as 75% in Quilon district and 70% in Alleppey district. It is the lowest in Trichur district (39%). In other districts the infestation varied from 59% to 66%. The association of *Oryctes* infestation with these diseases was also discussed.

**181. GOPINATHAN PILLAI, N.; SASIKALA, M. and MATHEN, K.** 1980. Epidemiology of coconut root (wilt) disease. *J. Plantn Crops* 8(2): 90-97. (CPCRI(RS), Kayangulam, Kerala).

Coconut root (wilt) disease of Kerala, (South India) is a debilitating disease. Out of 7,40,000 ha coconut plantation 2,50,000 ha

are affected by this malady causing an annual loss of about 340 million nuts. Association of fungi, bacteria, nematodes, and transmissible virus-like pathogens with the disease have been reported.

Observations recorded for seven years in 10 coconut gardens, each of approximately one ha extent with very low percentage of disease incidence revealed indiscriminate spread in sandy, sandy loam and alluvial soils. The percentages of disease incidence increased from 2.3 to 18.2 with 2.5 palms contracting infection every year. The spread of the disease is slower in laterite soil with only one palm developing the disease in two years. The spread was erratic and irregular irrespective of soil conditions. The rate of spread was 1-4 km from the nearest source of infection. The pattern of spatial distribution or galaxial out break of the disease is suggestive of the involvement of an aerial vector (s).

**182. GOVINDANKUTTY, M.P. and VELLAICHAMY, K.** 1976. Histopathology of roots of coconut palm affected with root (wilt) disease. In: Coconut research and development; proceedings the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976. Edited by N.M. Nayar. New Delhi: Wiley Eastern. p.421-425. (CPCRI (RS), Kayangulam, Kerala).

Anatomy of roots from healthy and diseased coconut palms were studied using serial microtome and free hand sections. Some externally healthy roots from apparently healthy and obviously diseased palms (naturally infected) from an area of active disease spread showed poorly staining mechanical and vascular tissues. Walls of tracheal elements were thinner and disorganized. Tyloses occurred occasionally in metaxylem vessels and several roots revealed degenerated phloem. Necrotic effects were shown by abnormally and deeply staining phloem with dense contents. Tissue generation was less pronounced in the

metaphloem. Many a healthy looking roots from apparently healthy and diseased palms had fungal hyphae in metaxylem. Sections of roots with external lesions of the burrowing nematode *Radopholus similis* revealed the presence of nematodes and their eggs in cortical burrows. Such burrows contained deeply staining cells encircled by abnormal sclerenchyma. Degenerative changes in conducting elements could derange the flow of nutrients and thereby contribute to root death due to starvation.

183. IYER, R.D.; RAO, E.V.V. BHASKARA and GOVINDANKUTTY, M.P. 1979. Super yielders in coconut. *Indian Fmg* 28(10): 3-5. (CPCRI, Kasaragod, Kerala).

Data are presented on the annual nut yields and other characteristics of 3 elite coconut palms found in a survey in a root (wilt) disease-free area and 6 palms in a disease prevalent area. One such palm in the latter area had an average yield of 471 nuts/year over a 3-year period under rainfed conditions, compared with a local average of about 60 nuts/palm/year.

184. JACOB, P.M. and RAWTHER, T.S.S. 1991. Varietal resistance. In: Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. p.67-71. (CPCRI(RS), Kayangulam, Kerala).

Data on the reaction of coconut cultivars and hybrids to root (wilt) disease has been discussed. A comprehensive breeding programme has been initiated involving disease free WCT and Chowghat Green Dwarf.

185. JAYASANKAR, N.P. 1983. Current trends on coconut root (wilt) disease. *Indian Cocon. J.* 13(9): 15-20. (CPCRI (RS), Kayangulam, Kerala).

Poor soil conditions due to continuous cultivation and inadequate agronomic prac-

tices have to a greater extent contributed to the decline in coconut production. Investigations on the actual cause of the root (wilt) disease are in progress. Proper management practices, irrigation, fertilizer application and the use of genetically superior quality seedlings would bring about high production in spite of the diseased conditions.

186. JAYASANKAR, N.P. and BAVAPPA, K.V.A. 1986. Coconut root (wilt) disease; past studies, present status and future strategy. *Indian J. agric. Sci.* 56(5): 309-328. (CPCRI(RS) Kayangulam, Kerala)

The root (wilt) disease is reviewed in relation to symptoms, diagnosis, epidemiology, etiology, control and present status in Kerala and parts of Tamil Nadu, where it is prevalent.

187. JAYASANKAR, N.P. and GEORGE, MATHEW. 1991. Etiology. B. Bacteria. In Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. P.17-18. (CPCRI (RS), Kayangulam, Kerala).

Under enrichment *Enterobacter cloacae* was the only bacterium found consistently associated with the coconut root (wilt) disease. Its ability as the potential plant pathogen has been brought out. Control trials revealed the ameliorating effect of the antibiotic oxytetracycline on the disease. Large scale pathogenicity trials failed to reproduce the characteristic symptoms.

188. JAYASANKAR, N.P.; GEORGE, MATHEW and LILY, V.G. 1991. Microbiology. In: Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. P. 61-66. (CPCRI (RS), Kayangulam, Kerala)

The microbial profile of the root zone of coconut palms in relation to the root (wilt) disease has been brought out. The profitability

of cultivating fodder crops in the interspaces of coconut palms in the diseased tracts has been discussed. The possibility of altering the microflora of the root surface of the palms by appropriate inter and mixed cropping has been suggested on the basis of the physiological characterization of Actinomycetes. Growth and nodulation of green manure crops in coconut basins and mycorrhizal symbiosis of VA type, in relation to the disease are also discussed.

189. JAYASANKAR, N.P. and RADHA, K. 1982. Coconut root (wilt) disease, a practical approach; "contain the disease and live with it." Edited by K.V.A. Bavappa and others. Technical Bulletin no.8. Sp. (CPCRI (RS), Kayangulam, Kerala).

A four pronged strategy for the management of root (wilt) disease has been described, comprising 1) eradication for containing the disease within the present geographical limits, 2) rehabilitation of affected plantations by adopting a set of package practices developed for improving productivity of affected gardens, 3) gradual elimination of the disease by selective eradication and re-planting and 4) intensification of investigation on the cause and control of root (wilt) disease.

190. JAYASANKAR, N.P.; SOLOMON, J.J.; RAWTHER, T.S.S.; JOSEPH, THOMAS and MURALIDHARAN, A. 1989. Coconut root (wilt) disease; a discourse. Kasaragod: CPCRI. Technical Bulletin no. 19. 12p. (CPCRI (RS), Kayangulam, Kerala).

This publication incorporates all the relevant information accrued from the research on root (wilt) disease. The information is given through answers in popular language to questions often raised by cultivators, extension workers, students etc. and thus will prove useful to them.

191. JOSE, J. and NEELAKANDAN. 1984. Root (wilt) a deficiency disease. *Indian Cocon. J.*

14(12): 12-14. (Dept. of Botany, Univ. Calicut, Calicut, Kerala).

It is observed that certain symptoms shown by root (wilt) diseased palms coincide with that of S, Mg and Ca deficient palms. Hence the possible contribution of deficiency of these elements to the root (wilt) disease is discussed.

192. JOSEPH, K.V. and JAYASANKAR, N.P. 1979. Phenol metabolism of the coconut palms (*Cocos nucifera* Linn.) in relation to root (wilt) disease. In: Symposium on Plantation Crops, 2nd, Ootacamund Jun. 26-29, 1979. Proceedings of PLACROSYM II. Edited by C.S. Venkataram and others. P.330-334. (CPCRI (RS), Kayangulam, Kerala).

Enzymatic assay with the acetone powder preparations of the coconut roots revealed an increase in the levels of polyphenol oxidase and peroxidase with the incidence and increase in intensity of coconut root (wilt) disease. The levels of free phenol in the coconut roots were comparatively low in the root (wilt) affected palms compared to the apparently healthy palms. The levels of phenyl alanine ammonia lyase were also higher in the coconut palms cultivated in the root (wilt) affected areas compared to the palms cultivated in the disease free region. The result are suggestive of an accelerated phenol metabolism characteristic of root (wilt) disease.

193. JOSEPH, THOMAS. 1978. Some fungi associated with root system of coconuts in root (wilt) affected area. *Curr. Sci.* 47(16): 586. (CPCRI (RS), Kayangulam, Kerala).

*Monacrosporium bembicodes*, *Graphium* sp., *Fusarium equiseti*, *Cylindrocarpon effusum*, *Penicillium spiculisporum*, and *Penicillium javanicum* were isolated from the roots of root (wilt) disease affected coconut palms.

194. JOSEPH, THOMAS and JAYASANKAR, N.P.

1981. A study on root decay in relation to coconut root (wilt) disease. *Indian Cocon. J.* 12(4): 1-3. (CPCRI (RS), Kayangulam, Kerala).

The aim of the experiment was to find out whether root (wilt) disease had any influence on the rate of root decay. Two groups of palms in two locations in sandy loam soils (with higher water table & low water table), each including 9 adult palms (3 healthy, 3 middle stage of disease and 3 advanced stage of disease) were selected. In each palm the root system in a zone of 3 m radius from the bole and depth of 2 m was exposed, washed, cut off and categorised and counted separately for each palm. Extent of decay and regenerative ability of roots in healthy and diseased palms did not show any significant difference. But palms with high water table which were submerged for prolonged periods showed rapid decay. Hence it is concluded that diseased palms could be maintained at productive and economic level for several years with proper management practices.

195. JOSEPH, THOMAS and JAYASANKAR, N.P. 1982. Evaluating root degeneration in coconut in relation to root (wilt) disease. *Pl. Dis.* 66(8): 667-669. (CPCRI (RS), Kayangulam, Kerala).

Neither root degeneration nor root regeneration in healthy and root (wilt) affected coconut palms was statistically significant. 8, 11 and 6% of roots in West Coast Tall palms and 3, 3 and 4% of roots in locally grown philippine palms are decayed in healthy trees, trees in the middle stage of the disease, and trees in advanced stage of the disease respectively. Observation confined to any sector of the root system were not representative of root characteristics.

196. JOSEPH, THOMAS and LILY, V.G. 1991. Etiology: A. Fungi. In: Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series, no. 3.

p.13-15. (CPCRI (RS), Kayangulam, Kerala).

Nearly one score of fungi have been reported to be associated with rotting of roots in cocout root (wilt) disease. Early studies showed that *Botryodiplodia theobromae* which was primarily implicated in the disease and *Rhizoctonia solani* and *R. bataticola* had constant association with root rotting. *R. solani* being confined to the roots of diseased palms was more specific. Also, it was able to elaborate pectin methyl esterase, polygalacturonase and pectin transesterase. In spite of inciting root rot, these fungi failed to cause development of the characteristic foliar symptoms of the disease. Lately, *Cylindrocarpon effusum* and *Fusarium equiseti* harboured by apparently healthy roots of the diseased palms and some roots having vascular discolouration, became implicated on account of the nature and extent of the damage they caused. However, they too failed to incite coconut root (wilt) disease when inoculated singly and in combination in test coconut seedlings maintained in microplots. Investigations accomplished up-to-date hardly proved the primary role of fungus in the syndrome.

197. JOSEPH, THOMAS.; GOPINATHAN PILLAI, N. and SOLOMON, J.J. 1991. Etiology; D. Virus. In: Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. p.27-30. (CPCRI (RS), Kayangulam, Kerala).

On account of the resemblance of the symptoms and positive mechanical and insect transmission in the field and under controlled conditions, the coconut root (wilt) disease was ascribed a viral origin. *Stephanitis typica* proved to be the vector. Its virulence was characterised by *Vigna unguiculata* (cowpea) which developed crinkling and malformation of the first trifoliate leaf subsequent to both the means of inoculation and became accepted as the indicator plant.

Besides the leaf, pollen, nuts, husk, kernel and embryo of coconut were also held to be infective. Presuming the infective principle to be a virus it was named as Coconut Wilt Virus. The physical properties and host range were studied. Culture of the virus was maintained in cowpea through serial inoculation. Based on the nature of symptoms developed by the sap-transmissible agents on cowpea, involvement of spirochaetae or sporozoa had to be suspected in place of virus. Cowpea started behaving inconsistently and had to be treated as unreliable. Elsewhere, purified preparations from diseased coconut leaf infected *Chenopodium amaranticolor* and *Nicotiana tabacum*. Associated virus particles were characterised. Based on the positive reactions of these to three strains of tobacco virus, the workers named the agent as TMV. Contrarily, the non-involvement of TMV in the coconut root (wilt) disease was later established through pathogenicity, EM studies and serology. Also particles once described as icosahedral were later identified as plasmodesmata. A virus etiology to coconut root (wilt) disease still remains short of substantial evidence such as visualization of the particles in EM and consistent response of the reported indicator plant namely cowpea to infection.

198. JOSEPH, THOMAS, and RAWTHER, T.S.S. 1991. Leaf rot disease. In: Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. p.81-89. (CPCRI (RS), Kayangulam, Kerala).

Leaf rot occurs superimposed on root (wilt) diseased palms. It was in reports since 1880 in the erstwhile states of Travancore and Cochin. Palms growing in all types of soils and of all ages except seedlings are susceptible to the malady. Intensity of the disease increases with advancement of age and severity of root (wilt) disease. *Bipolaris halodes* (Drechs.) chiefly incites the infection. Annual loss in yield due

to the disease has presently been computed as 461 million nuts and the area under infection 0.41 million ha. Characteristically, the distal portions of the leaflets rot because the tissues are soft on the spindle leaves. Hardening of the tissues below, prevents spread of the lesions further and the affected leaves assume a fan-like appearance. Although non-lethal, if the progress of leaf rot disease is unchecked, all the leaves in the palm would manifest symptoms gradually. Weather factors play definite role in the incidence and disease is air-borne. With the aid of aeroscope spores of other fungi like *Gloeosporium* sp. and *Pestalotia* sp. were also observed along with *B. halodes* infection on coconut. Pathogenicity trials with various fungi indicated that inoculation with *B. halodes* singly incited 84 percent infection and when cultures were combined with other fungi infection was 93 percent. Use of synthetics was not prophylactically successful. Foliar spraying of Bordeaux mixture (1%), controlled 76.6% infection. However, sequential spraying with Bordeaux mixture (1%), Dithane-M45 (0.3%) and Fytolan (0.5%) provided 87.8% control. Beneficial effects of aerial spraying remains controversial.

199. KAMALADEVI, C.B.; NARASIMHAYYA, G.; WAHID, P.A.; NAMBIAR, C.K.B.; PILLAI, N.G.; SHARMA, S.P. and VELAYUTHAM, M. 1981. Discriminant classification of Kerala soils in relation to incidence of coconut root (wilt) disease 1. Soil micronutrient aspects. Philip. J. Cocon. Studies 6(1): 40-45. (CPCRI (RS), Kayangulam, Kerala).

The analyses of the nutrient data on the soil samples in Kerala collected from the different root (wilt) disease categories depending on the condition of the palm and the area samples suggest the list of essential nutrients for the discrimination of the soils as: 1. Laterite = Fe, B, Mn, Mo, Cu, S and Zn 2. Alluvial = Fe, Mo and Zn 3. Reclaimed marshy = Fe, Zn, Cu, Mo, Mn and B 4. Coastal Sand = Fe, Zn,

Cu and 5. Sandy loam = Mn, Cu and Zn.

The classificatory analysis of the above data on the essential nutrients showed that soils of the above categories can be grouped into three clusters namely healthy, leading to sick and sick in case of laterites, reclaimed marshy, sandy loam and two clusters as follows: healthy and sick in case of alluvial and coastal sandy soils.

200. KAMALAKSHY AMMA, P.G.; CECIL, S. ROBERT.; GOPINATHAN PILLAI, M.; MATHEW, A.S. and NAMBIAR, P.T.N. 1982. Performance of Dwarf x Tall hybrid coconut in root (wilt) affected areas of Kerala under different fertilizer levels. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.405-410. (CPCRI (RS), Kayangulam, Kerala).

A field experiment was conducted to study the performance of Dwarf x Tall hybrid coconut palms under different fertilizer levels in the root (wilt) disease affected areas. With the lowest level of fertilizer application, an average yield of 120 nuts/palm/year was obtained. 500 g N, 300g P<sub>2</sub>O<sub>5</sub> and 1000 g K<sub>2</sub>O with 500g MgO could be taken as the ideal dose of fertilizer application in the early bearing periods under rainfed conditions. About 22 percent of the total palms had contracted root (wilt) disease at the end of ninth year from planting.

201. KAMALAKSHY AMMA, P.G.; SETHUMADHAVA MENON, K.; PATIL P.B. and SADANANDAN, A.K. 1982. Effect of mixed cropping with cacao in coconut root (wilt) affected garden. *Indian Cocon. J.* 13(4): 14-17. (CPCRI (RS), Kayangulam, Kerala).

Root (wilt) disease of coconut has affected about 12 million palms in about 2,50,000 ha which accounts for nearly one third of the total area under coconut in Kerala. The economic

losses due to the disease are estimated at Rs.300 million annually. The etiology of this complex malady is yet to be fully understood and as such no specific control measures could be recommended against it. Though there are several reports on the profitability of raising cocoa as a mixed crop in coconut gardens, no data are available on the feasibility or otherwise of raising cacao as a mixed crop in coconut gardens affected by root (wilt) disease. Hence studies were initiated to investigate the effect of growing cacao as a mixed crop in root (wilt) affected coconut garden, with reference to the change in soil fertility, yield response of coconut and cacao and the economic gains. Mixed cropping with cacao increased soil fertility and there was no deterioration of the disease condition of palms. There was 30 percent increase in yield of palms.

202. KERALA AGRICULTURAL UNIVERSITY, TRICHUR. 1989. Investigation on root (wilt) disease of coconut palm in Kerala; report on the research project, phase I period (1981-85). 109 p.

Research work carried out on Agronomy, Agricultural Chemistry, Nematology, Entomology and Plant Pathology is presented with reference to root (wilt) disease of coconut.

203. KHAN H. HAMEED.; BIDDAPPA, C.C.; JOSHI, O.P. and CECIL S. ROBERT. 1985. Micronutrient distribution in the crowns of healthy and root (wilt) diseased palms. *J. Plantr Crops* 13(1): 66-69. (CPCRI, Kasaragod, Kerala).

Relationship of micronutrient contents of the coconut palm with the root (wilt) disease is studied sampling fronds 1, 4, 9, 14 and the last functional leaf. The concentration of Cu, Zn and Mn were higher and the distribution found in the crown was also altered due to incidence of disease. No correlation was obtained between elemental concentration and disease index. The contents of micronutrients

and the trend of distribution in the crown indicated loss of selectivity in the absorption and distribution of nutrients.

204. KOCHU BABU, M.; RADHA, K.; RETHINAM, P. and ANTONY, K.J. 1985. Coconut root (wilt) disease in Trichur district; 2. Observations on disease recurrence. *Indian Cocon. J.* 16(4): 10–16. (CPCRI (RC), Kannara, Kerala).

Four hundred coconut root (wilt) affected palms distributed in eight villages north of Karuvannur river in Trichur district, Kerala were eradicated to prevent the spread of the disease further north. Observations on disease recurrence in the affected gardens were recorded periodically. Out of 209 gardens from which 400 root (wilt) disease affected palms were eradicated, 193 gardens with disease recurrence are located in low lying areas of hill slopes and river bed. Eradication is more effective in gardens where initial incidence of disease was low. Young palms are more susceptible to the disease. Within the diseased gardens spread of the disease was erratic.

205. KURIAN, JOHN, M. 1983. Subsidy for removal and rejuvenation of root (wilt) affected palms in Kerala. *Indian Cocon. J.* 13(9): 24–27. (Coconut Dev. Board, Cochin, Kerala)

The root (wilt) disease appears in all soil types and there is no effective remedy for this. The present strategy is to combat the disease within peripheral belts, rehabilitation of the affected palms etc. Different subsidy schemes for replanting programmes are discussed.

206. LILY, V.G. 1979. Preliminary studies on the association of *Fusarium equiseti* (Corda) Sacc and *Cylindrocarpon effusum* Bugn. with coconut root (wilt) disease. In: Symposium on Plantation Crops, 2nd, Ootacamund, Jun. 26–29, 1979. Proceedings of PLACROSYM II. Edited by C.S. Venkataram and others. p.325–329. (CPCRI, (RS), Kayangulam, Kerala).

Root decay is often found to be asso-

ciated with coconut root (wilt) disease. Evidence suggest the association of some fungi in causing root damage.

Recently *Fusarium equiseti* and *Cylindrocarpon effusum* were isolated from apparently healthy roots of root (wilt) affected and also apparently healthy palms of diseased tract. Pathogenicity trials indicated the ability of these fungi to cause internal damage prior to the development of external symptoms in roots as evidenced by the derangements observed at the stelar region. As the infection progressed, acute symptoms were noticed, exhibiting black necrotic patches on the mature roots and also rotting of the root tip. The number of rotted roots increased as the period of incubation prolonged resulting in a deteriorated root system as occurring in root (wilt) affected palm.

207. LILY, V.G. 1981. Host parasitic relations of *Bipolaris halodes* (Drechs.) Shoemaker on the coconut palm. *Indian Cocon. J.* 11(11): 1–4. (CPCRI (RS), Kayangulam, Kerala)

The frequent association of leaf rot with the root (wilt) disease resulting in serious dealing on the productivity of the coconut palms has been observed in the root (wilt) affected tracts of Kerala. The initial focus of infection is the tender unopened leaf of the palm and the organism causing the disease has been identified as *Bipolaris halodes* (Drechs.) Shoemaker. Studies on the preference for tender most leaves as sites of infection revealed that the thickness of the epidermal layer of the leaf increased with age, the tendermost leaf having a mean thickness of 695 $\mu$  as against 954 $\mu$  in the mature leaf. The percentage of moisture content was maximum in the tendermost leaf (77–95) and it reduced to 61.33 in mature leaf. Results of tissue analyses indicated higher concentrations of total nitrogen, non-protein and protein nitrogen in the tender most leaf (2.08 mg/g; 1.71 mg/g; 0.37 mg/g respectively on oven

dried basis) and it came down to 1.05 mg/g; 0.87 mg/g and 0.18 mg/g respectively in fully matured leaf. A field experiment conducted to investigate whether proper nutrition of coconut seedlings with N, P, K, Ca and Mg nutrients could provide any tolerance to infection by *B. halodes* revealed that although the leaf tissue took up infection, the severity of the same was only minimal in the seedlings receiving - treatments of NPK with calcium and magnesium as compared to that in seedlings receiving other treatments. This result also indicates the importance of Ca and Mg nutrition of coconut palms in disease affected tracts.

208. LILY, V.G. 1981. Pathogenicity of *Cylindrocarpon lucidum* on coconut palms, a short scientific report. *J. Plantn Crops* 9(1): 59-61. (CPCRI (RS), Kayangulam, Kerala).

Root decay associated with root (wilt) disease of coconut palm is reported to be due to fungal infection. Recent studies revealed that *Fusarium equiseti* (Corda) Sacc. and *Cylindrocarpon effusum* Bugn. are also pathogenic to coconut root system. This note describes the results of pathogenicity trials conducted on seedlings with *C. lucidum* Booth, a fungus isolated from coconut root.

209. LILY, V.G. 1981. Possible association of *Fusarium equiseti* and *Cylindrocarpon effusum* in coconut root (wilt) disease. *Indian Phytopathol.* 34(3): 369-370. (CPCRI (RS), Kayangulam, Kerala).

A short scientific note on the occurrence of *F. equiseti* and *C. effusum* in the root (wilt) affected coconuts. The presence of micro organism was determined in healthy and root (wilt) affected seedlings. Observations on the complete root system of the inoculated seedlings indicated 20 per cent root rot in *F. equiseti* inoculated seedlings as against 13.5 percent in *C. effusum*, while there was 5 percent roting in the uninoculated check palms.

210. LILY, V.G. 1983. Toxic effect of *Fusarium equiseti* an isolate from coconut root. *Indian Phytopath.* 36(1): 164-165. (CPCRI (RS), Kayangulam, Kerala).

The present study was carried out to assess the toxin production by *F. equiseti* and its effect on coconut leaf tissue, coconut sprouts and napier grass. The results indicated the presence of toxin in the culture filtrate of the fungus as it produced wilting in the test plant and roting in leaves of coconut.

211. LILY, V.G. and PILLAI, N.G. 1980. Association of fungi with coconuts producing rubbery copra in root (wilt) affected areas. *Indian Cocon. J.* 11(1): 1-2. (CPCRI (RS), Kayangulam, Kerala).

Production of low quality rubbery copra was observed in the root (wilt) affected gardens. Softening of husk and shell and blackening of shell are common symptoms of the disease. Investigations indicated that the disease was due to a possible association of fungi.

212. MARAMOROSCH, K. and KONDO, F. 1977. Electron microscopy of leaf section from Kerala wilt diseased coconut palm. *J. Plantn Crops* 5(1): 20-22. (Wakesman Institute of Microbiology, Rutgers, The State Univ. of Jersey, P.O.Box 759, Piscataway, New Jersey, USA)

Electron micrographs of thin sections of coconut palm leaves from Kerala root (wilt) affected palms revealed the presence of two types of submicroscopical particles. One type was the commonly encountered phytoferritin which forms characteristic accumulation in diseased leaves. The other represent virus like particles. Further studies might reveal whether the virus like particles are constantly associated with the Kerala root (wilt) disease.

213. MATHAI, G. 1978. Search for root (wilt) disease resistance in coconut. *Indian Cocon. J.* 9(6): 7-8. (Coconut Res. Station, KAU,

Kumarakom, Kottayam, Kerala).

A list of hybrids/varieties planted for screening trials with the object of finding out a variety resistant or tolerant to the root (wilt) disease is given in a table.

Preliminary observation indicated that within a period of 5 years all the hybrid/varieties became infected with the disease. There are indications of tolerance by the variety Laccadive Dwarf (Index = 5.8) while West Coast Tall and Tall x Dwarf showed an intensity of disease index of 52.0 and 67.6 respectively. Laccadive Dwarf and its hybrid progenies are subjected to further investigations.

214. MATHAI, G. 1980. Seasonal and varietal variations on the incidence of leaf rot of coconut in the root (wilt) affected tracts. *Indian Cocon. J.* 11(6): 1-3. (Coconut Res. Station, KAU, Kumarakom, Kerala).

The results of studies conducted on the seasonal and varietal variations on the incidence of leaf rot in the root (wilt) affected tracts of Kerala are presented in this paper. The results indicated that leaf rot disease intensity was higher during September-October when the north east monsoon showers are received in the area. Among nine hybrid/varieties tested T x D followed by T x NYG recorded lowest incidence of leaf rot. Hybrid T x NYG followed by T x LD was found tolerant to root (wilt) disease. The intensity of leaf rot was comparatively low in those varieties where a lesser incidence of root (wilt) was observed and the correlation-coefficient computed were statistically significant.

215. MATHAI, G.; INDRASENAN, G. and KUNJU, U., MOHAMED. 1984. Investigations on the integrated control of root (wilt) disease of coconut. *In: Symposium on Plantation Crops, 6th, RRII, Kottayam, Mar. 16-20, 1984. Proceedings of PLACROSYM VI.* Edited by M.R. Sethuraj and others. p.99-105. (Coconut Res.

Station, KAU, Kumarakom, Kerala).

Trials on integrated control of root (wilt) disease indicated that the disease is incited by an organism or entity which is unaffected by a nematicide, bactericide or a fungicide. Different treatments employed are discussed in detail.

216. MATHAI, G.; MATHEW, JAMES and BALAKRISHNAN, B. 1988. Reaction of exotic cultivars of coconut (*Cocos nucifera* L.) to root (wilt) disease of Kerala. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov.23-26, 1988. Abstracts of papers.* p.19. (RARS, KAU, Kumarakom, Kerala).

The degree of resistance/tolerance of ten exotic and geographically distinct cultivars to root (wilt) disease was studied. All the exotic cultivars tested were susceptible to the disease with varying degrees of intensity. However, the cultivar San Ramon recorded significantly lower disease incidence followed by Guam, St. Vincent and Kenya. The infection of leaf rot incited by *Bipolaris halodes* (Drechs) Shoemaker was also low in these cultivars.

217. MATHAI, G.; MATHEW, A.V. and KUNJU, U. MOHAMED. 1985. Reaction of coconut cultivars (*Cocos nucifera* L.) to root (wilt) and leaf rot diseases. *Indian Phytopath.* 38(3): 561-562. (Coconut Res. Station, KAU, Kumarakom, Kottayam, Kerala).

Screening trials conducted with eight cultivars against coconut root (wilt) disease indicated a significantly lower incidence in the variety Andaman ordinary followed by SSG and Cochin China. Reaction to leafrot incidence were also reported.

218. MATHAI, G. and NAIR, K.P.V. 1978. Effect of soil application of fertilizers and micronutrients on root (wilt) disease and yield of coconut in the backwater region of Kerala. *Agric. Res. J.*

*Kerala* 16(2): 244–246. (Coconut Res. Station, KAU, Kumarakom, Kottayam, Kerala).

Application of NPK alone or with either, boron, manganese, copper, molybdenum or zinc, or all the 5 to diseased plots, showed that zinc tended to increase yield as did higher application of N P K.

219. MATHAI, G. and NAIR, K.P.V. 1979. Effect of residue salt bitten on the yield and foliar yellow intensity of coconut palm. *Agric. Res. J. Kerala* 17(1): 133–135. (Coconut Res. Station, KAU, Kumarakom, Kottayam, Kerala).

In trials with 35–40 year old coconuts, residue salt bitten was applied to the soil and sprayed on the foliage. Soil application alone decreased the yield below to that of the control. No effect of residual salt on the foliar yellowing was observed.

220. MATHAI, G. and THOMAS, B. 1979. Sequence of occurrence and intensity of foliar symptoms of root (wilt) disease on coconut seedling palms. *Indian Cocon. J.* 10(7): 3–4. (Coconut Res. Station, Kumarakom, Kerala).

The symptoms of root (wilt) disease are complex and variable. It is said that the flaccidity or ribbing of leaflets was the common symptom, Foliar yellowing and marginal necrosis are of secondary importance. A survey was carried out with young seedling palms of different cross combinations to evaluate quantitatively the foliar symptoms, based on sequence and the frequency of occurrence.

221. MATHEN, K. 1982. Comparative abundance of the tingid vector *Stephanitis typica* (Distant) in root (wilt) disease affected and healthy coconut palms in Kerala. In: All India Symposium on Vectors and Vector borne Diseases, Trivandrum, 1982. Proceedings of the symposium. p.29–33. (CPCRI (RS), Kayangulam, Kerala).

The comparative abundance of individu-

als of *Stephanitis typica* on healthy coconut palms and those affected with coconut root (wilt) disease was studied in diseased and disease-free areas of Kerala, India in 1972-74. Tingid populations were generally greater on diseased trees than on healthy ones. Consistent differences in tingid numbers were not observed between the three categories of diseased trees: those not yet showing symptoms, those in the early stages and those in the advanced stages of disease. In another study the number of adults and nymphs was about four times greater on diseased coconut seedlings than on healthy ones from the same area.

222. MATHEN, K. 1985. Lace bug abundance in root (wilt) disease affected coconut palms, cause or effect. *J. Plantn Crops* 13(1): 56–59. (CPCRI (RS), Kayangulam, Kerala).

Correlation between the number of lace bug *Stephanitis typicus* (Distant), on apparently healthy coconut palms in root (wilt) disease-prevalent tract and incidence of the disease on the same lot of palms in subsequent years brought out in ascending order of fresh incidence of root (wilt) with increase in abundance of the insect, thus implying an indirect role in transmission.

223. MATHEN, K.; GOVINDANKUTTY, M.P. and MATHEW, CHACKO. 1979. Nature and extent of damage to coconut as a result of feeding by *Stephanitis typicus* (Distant) (Heteroptera: Tingidae). In: Symposium on Plantation Crops, II, Ootacamund, Jun. 26–29, 1979. Proceedings of PLACROSYM II. Edited by C.S. Venkata Ram and others. p.466–473. (CPCRI(RS), Kayangulam, Kerala).

The lace bug *Stephanitis typicus* (Distant) a minor pest of coconut, assumes importance because of its reported role as vector of coconut root (wilt) disease. Inoculation of palms in the field and of seedlings under insect proof green house had brought about transmission of the disease. The nature and extent of damage

to coconut pinnae are discussed here on the basis of feeding marks, histology and chlorophyll analysis.

Both adults and nymphs feed from the lower surface of coconut pinnae, leaving permanent chlorotic spots on the adaxial surface. These yellow scars vary from small pinpricks to large coalesced patches with an average area of 0.112 mm under laboratory conditions. The mean number of feeding marks produced by one adult in 24h was 80. An average area of 8.96 mm is therefore dechlorophyllated by a single insect per day. With an average count of 490 adults on the crown of a palm the total area rendered unsuitable for photosynthesis is 4390 mm/day. The removal of chlorophyll per adult per day is to the tune of 0.24 g per gram fresh weight or 0.78 g/cm<sup>2</sup> of leaf. Not only the chlorophyll, but the entire cell contents are drained while feeding. The palisade cells are depleted of cell contents. A stylet sheath is not made out and evidence of a prominent role of saliva during feeding is little.

224. MATHEN, K.; GOPINATHAN PILLAI, N. and RADHA, K. 1983. A terminology for the coconut root (wilt) disease. *In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec.27-31, 1976*, edited by N.M. Nayar. New Delhi. Wiley Eastern. p.342-346. (CPCRI (RS), Kayangulam, Kerala).

Coconut root (wilt) disease has been referred to by various authors under different names. The variations in the name have created confusion among readers and reviewers to mistake the disease for other disorders in the coconut palm. A list of all such names used in the literature hitherto is given in alphabetical order. A chronological order of the variations is cited. Suitability of each name is discussed. From among the available names, coconut root (wilt) disease is chosen and recommended for use by all workers for the sake of uniformity,

until such time as a new name can justifiably replace it.

225. MATHEN, K.; JOSEPH, THOMAS; PILLAI, G.B.; MATHEW, CHACKO and CECIL, S. ROBERT. 1980. A discourse on coconut root (wilt) disease. Edited by N.M.Nayar. Kasaragod: CPCRI. p.40. (CPCRI (RS), Kayangulam, Kerala).

In this pamphlet an attempt has been made to explain what root (wilt) disease is, and how best to manage, through answers in popular language to questions often raised by cultivators.

226. MATHEN, K.; GOPINATHAN PILLAI, N.; MATHEW, A.S. and SHANTA, P. 1976. Reproduction of symptoms of root (wilt) disease of coconut in potted coconut seedlings. *J. Plantn Crops* 4(2): 78-79. (CPCRI (RS), Kayangulam, Kerala).

The first results of a trial with coconut seedlings in pots with disease infected soils of different calcium and magnesium content indicates a lower disease index score for the plants growing in a soil with a higher Ca and Mg content.

227. MATHEN, K.; RAJAN, P.; RADHAKRISHNAN NAIR, C.P.; SASIKALA, M.; GUNASEKARAN, M.; GOVINDANKUTTY, M.P. and SOLOMON, J.J. 1990. Transmission of root (wilt) disease to coconut seedlings through *Stephanitis typica* (Distant) (Heteroptera: Tingidae). *Trop. Agric.* 67(1): 69-73. (CPCRI (RS), Kayangulam, Kerala).

Two-year-old West Coast Tall coconut seedlings obtained from a disease-free area in Kerala, India, were planted in methyl bromide-fumigated loamy sand collected from paddy fields, held in field tanks and protected inside netted field cages. The seedlings were regularly inoculated with infective adults of *Stephanitis typica*. Spear-leaf tissues of 3 of the 4 experimental seedlings gave strong positive serological reactions, indicating infection, 9 months

after the first inoculation. Root tissues treated with Dienes' stain, DAPI and Hoechst 33258 flouochromes indicated mycoplasma-like organism (MLO) infection in the phloem. Serological and stain reactions in the 4th seedling were feeble at that time. Electron microscopic examination of ultra-thin sections of root apexes of all the seedlings revealed the presence of mycoplasma-like organisms in the sieve tubes. Of the 4 seedlings to which MLOs were transmitted by tingids, 2 developed flaccidity of leaflets, the diagnostic and decisive symptom of the disease, 8 months after infection was indicated by serodiagnosis. By the time the seedlings were visually identified as manifesting the symptom of the disease, each seedling had received more than 1000 adults with 5 days' acquisition feeding on diseased palms known to harbour MLOs and about 1130 adults with 5 days' acquisition and 13 days' incubation. Control plants remained free of the organism and the symptoms of the disease.

228. MATHEN, K.; SOLOMON, J.J.; RAJAN, P. and GEETHA, L. 1987. Electron microscopic evidence on the role of *Stephanitis typica* (Distant) as vector of coconut root (wilt) disease. *Curr. Sci.* 56(23): 1239-1240. (CPCRI (RS), Kayangulam, Kerala).

Electron microscopic studies were carried out to investigate the presence of mycoplasma like organisms (MLOs), which are associated with root (wilt) diseased palms, in the tissues of lace bug *Stephanitis typica*. The salivary gland and brain tissues of the insects after acquisition and incubation period of more than 18 days revealed the presence of large number of MLOs. The spherical bodies surrounded by distinct unit membrane, were about 250-500 nm in diameter. Out of two forms of bodies observed one was smaller, spherical and filled with electron dense material while the other was large fibrillar nuclear material with peripheral ribosomes. MLOs were absent

in salivary glands of lace bugs, collected from disease-free location: Kasaragod and Minicoy (Lakshadweep). This study offers the evidence of the bugs acquiring the MLOs, sustaining their multiplication and eventually effecting their occupation in salivary gland.

229. MATHEW, A.S.; JOSE, A.I.; ABRAHAM, JOSE; CECIL, S. ROBERT and KAMALAKSHY AMMA, P.G. 1986. Effect of zinc and molybdenum on root (wilt) affected coconut palms. *Agric. Res. J. Kerala* 24(2): 169-174. (CPCRI, (RS), Kayangulam, Kerala).

A micronutrient trial using Zn and Mo as foliar and root application was conducted on root (wilt) disease affected palms and under different stages of diseases for a period of four years. The study indicated that applications were not effective either in reducing the intensity of disease or in increasing the yield of palms.

230. MATHEW, A.S. and VARKEY, THOMAS. 1977. Calcium and magnesium status of soils and leaves in relation to root (wilt) disease of coconut. *J. Plantn Crops* 4(2): 54-56. (CPCRI (RS), Kayangulam, Kerala).

Soil and leaf samples were collected from healthy and root (wilt) disease infected tracts. The status of Ca and Mg of soil and leaf was not correlated with the incidence of root (wilt) disease in coconut.

231. MATHEW, CHACKO. 1977. Changes in carbohydrate content of coconut palm affected by root (wilt) disease. *J. Plantn Crops* 5(2): 84-88. (CPCRI (RS), Kayangulam, Kerala).

Changes in the carbohydrate content were studied in root (wilt) disease-infected coconut palms. Total reducing and non-reducing sugars were higher in the leaves of infected palms. A depletion of these sugars was observed in the roots of diseased palms, indicating thereby a possible block in translocation. Starch and total carbohydrates were

at a reduced level in the leaves and roots of infected palm.

232. MATHEW, CHACKO. 1981. Water relations of coconut palm affected by root (wilt) disease. *J. Plantn Crops* 9(1): 51-55. (CPCRI, (RS), Kayangulam, Kerala).

An investigation was undertaken to determine the status of transpiration and water content of leaves and cell and stomata frequencies per unit area of epiderma in coconut palms affected by root (wilt) disease. Significant increases in transpiration rate and water content of leaves were noticed in diseased palms. The frequency of epidermal cells and stomata per unit area of leaf was greater in diseased palms, though the stomatal index did not differ significantly between healthy and diseased palms. The existance of an internal water deficit in diseased palms has been indicated.

233. MATHEW, CHACKO and VARKEY, THOMAS. 1979. Some aspects of foliar yellowing in coconut. *Indian Cocon. J.* 9(8): 1-2. (CPCRI (RS), Kayangulam, Kerala).

Causes responsible for the foliar yellowing of coconut have been identified.

234. MATHEW, CHACKO; RAJAGOPAL, V.; VARKEY, THOMAS. and JOSEPH, K.V. 1991. Physiology and biochemistry. *In: Coconut root (wilt) disease.* Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph series 3. p.53-59. (CPCRI (RS), Kayangulam, Kerala).

Root (wilt) affected coconut palms showed marked changes in some of the physiological and biochemical processes. Root activity was assessed through absorption permeability studies, supported by radioactive phosphorus and enzyme assays. Attempts were made to regenerate the roots through chemical treatments involving hormones and phenols. Investigations on the water relations aspects like stomatal regulation and leaf water potential

reflected on the disease symptom like flaccidity. Activities of enzymes like carbonic anhydrase polyphenol oxidase and peroxidase showed variations with the intensity of the disease.

235. MICHAEL, K.J. 1978. Rate of photosynthesis in coconut palm affected by root (wilt) disease (Abstract). *In: Symposium on Plantation Crops, 1st, RRIL, Kottayam, Mar. 20-23, 1978.* Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p.372. (CPCRI (RS), Kayangulam, Kerala).

Reduction in the rate of photosynthesis was observed in disease affected palms with a corresponding reduction in the dry matter production.

236. MURALIDHARAN, A.; JAYASANKAR, N.P.; ANTONY, K.J. and RETHINAM, P. 1991. Management of coconut root (wilt) disease. *In: Coconut root wilt disease.* Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. p.73-80. (CPCRI (RS), Kayangulam, Kerala).

Studies on the root (wilt) affected palms recommended a balanced dose of fertilizer application to palms/year along with 500 g MgO. Eradication of disease advanced palms after spraying with carbaryl prevented recurrence of disease in some affected areas. Multiple cropping, intercropping with cassava, elephant footyam and greater yam and mixed farming in the root (wilt) affected gardens exert ameliorating effect on the diseased palms.

237. MURALIDHARAN, A.; GOPALAKRISHNAN NAIR, M. and JAYASANKAR, N.P. 1986. Response of coconut root (wilt) disease to management practices. *Indian Cocon. J.* 17(1): 3-6. (CPCRI (RS), Kayangulam, Kerala).

In trials at 6 localities the palms were classified into apparently healthy (AH), disease early (DE), disease middle (DM) and disease advanced (DA). The management practices

consisted of an integrated adoption of 10 methods including removal of highly infected palms, gap filling, nutrition, treatment with fungicides, intercropping and weed control. The response to treatments was best in AH followed by DE, where during the 3rd year of treatments yield increases over the untreated control palms were 39 and 28.4%, respectively.

238. NAYAR, N.M. and JAYASANKAR, N.P. 1981. The root (wilt) disease; a status report. Technical Bulletin no.5, 26 p. (Mimeo.) (CPCRI, Kasaragod, Kerala)

This publication give an overview of root (wilt) disease, the magnitude of the problem and a summary of the research work done and in progress. Management practices for containing the disease and increasing yield of diseased palms are described.

239. NAMBIAR, P.T.N. 1983. Decline in yield and the effect of management practices on root (wilt) affected coconut palm. *Indian Cocon. J.* 14(11): 3-4. (CPCRI, (RS), Kayangulam, Kerala).

Significant negative correlation was observed between the disease intensity and yield of palms. However, it is possible to increase the yield of disease affected palms by good management. It is more economical to rejuvenate the younger palms than the older disease affected palms.

240. NAMBIAR, P.T.N. and GOPINATHAN PILLAI, N. 1985. A simplified method of indexing root (wilt) affected coconut palms. *J. Plantn Crops* 13(1): 35-37. (CPCRI (RS), Kayangulam, Kerala).

The earlier method of indexing the severity of root (wilt) disease of coconut was based on flaccidity, yellowing and necrosis, the three major visual symptoms on all the leaves on the crown. An attempt has been made to simplify the method of the indexing by

taking into account only the leaves present in any of the five spirals. It is possible to work out the disease index from the symptoms present in the leaves of third spiral in about 10 minutes as against over 30 minutes required for indexing by the earlier method.

241. PADMAJA, G. and SUMATHYKUTTY AMMA, B. 1979. Cellulase activity in the root of coconut palms affected by root (wilt) disease. *J. Plantn Crops* 7(2): 101-104. (CPCRI, (RS), Kayangulam, Kerala).

Cellulase activity was determined in the roots of healthy and root (wilt) diseased coconut palms. Higher activity was obtained in the diseased palms when compared to the healthy ones. The results of the study indicate that cellulase might be one of the factors responsible for the vast decay of roots observed in the diseased palms.

242. PADMAJA, G.; SUMATHYKUTTY AMMA, B.; MATHEW, CHACKO; NAMBIAR, P.T.N. and DWIVEDI, R.S. 1981. Alterations in the leaf protein content of coconut affected by root (wilt) disease. *Indian J. Pl Physiol.* 24: 42-46 (CPCRI (RS) Kayangulam, Kerala).

Changes in the protein content of leaves from healthy and root (wilt) affected coconut palms have been studied. Alkali extractable, water-extractable and ethanol-extractable protein fractions were found to be higher in the healthy palms when compared to the diseased palms. A preferential extraction of protein at low values could be obtained in the middle and outer leaves from apparently healthy and diseased palms. An increase of 53.7% and 24.9% over the protein values in the healthy palms was noticed in the middle and the outer leaves, respectively of the apparently healthy palms while the increase was 42.8% and 14% in the respective leaves of diseased palms. The implications of the protein changes in root (wilt) disease have been discussed.

243. PARTHASARATHY, M.V. 1978. Have virus like particles been found in leaf of Kerala wilt diseased coconut palms? - Not yet. *J. Plantn Crops* 6(2): 87-89. (Section of Botany, Genetics and development, Plant Science Building, Cornell University, Ithaca, New York, 14 853, U.S.A.).

The icosahedral submicroscopical particles, 56 nm in diameter, observed by Maramorosch and Kondo (1977) in the epidermis and ground parenchyma cells of coconut root (wilt) diseased leaf tissues, and claimed to be "virus-like" by them, are actually transverse to slightly oblique sections of plasmodesmata. The presence of virus-like particles, 56 nm in diameter, is yet to be demonstrated in the root (wilt) diseased coconut palms.

244. PATIL, K.D. and MATHEW, CHACKO. 1982. The root (wilt) problem of coconut: a physiological approach. *Indian Cocon. J.* 12(6-9): 19-20. (CPCRI (RS), Kayangulam, Kerala).

A brief scientific note on etiology, symptom and dispersal of the root (wilt) problem has been presented. The disease is claimed to have been brought under control with the treatment of ascorbic acid, certain phenols and some micronutrients.

245. PILLAI, N.G.; KAMALA DEVI, C.B.; WAHID, P.A. and NAMBIAR, C.K.B. 1983. Available micronutrient status of major soil types under coconut in healthy and root (wilt) affected tracts of Kerala. In: *Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976*, edited by N.M. Nayar. New Delhi. Wiley Eastern. p.144-151. CPCRI (RS), Kayangulam, Kerala).

A survey of coconut plantations in Kerala State was carried out. Seven hundred and thirty-three surface soil samples were collected at about 6.5 km intervals and analyzed for available micronutrients in five major soil types.

Because of the low values encountered in a majority of cases, the following soil types are more likely to be deficient in certain elements: coastal sandy and reclaimed marshy soils for Mn, sandy loam soils for Zn, sandy loam and coastal sandy soils for Mo and coastal sandy soils for B. The distribution of available Cu was uniform in the different soil types excepting coastal sandy soils.

The root (wilt) disease affected tracts showed a significant reduction in the levels of the micronutrients such as Fe, Mn and Zn as compared to the healthy tracts.

246. POTTY, V.P. 1977. Rhizosphere microflora of coconut palm in relation to root (wilt) disease. Ph.D. Thesis. University of Kerala, Trivandrum. (CPCRI (RS), Kayangulam, Kerala).

The root (wilt) affected palms harboured higher numbers of actinomycetes, bacteria and fungi in the rhizosphere as compared to healthy palms. Mixed farming increases the total microflora as well as the population of symbiotic N<sub>2</sub> fixers and P solubilizers.

247. RADHA, K. 1977. Management of coconut gardens affected by root (wilt) disease. *Indian Cocon. J.* 8(8): 1-29. (CPCRI (RS), Kayangulam, Kerala).

Hygiene and sanitation are considered as prerequisites for the control of any infectious disease. As root (wilt) has been considered infectious it has been considered necessary to plant seedlings in soils not mixed up with any material contacted with the diseased palms.

In removing the diseased palms it is recommended to remove the bole and the roots to the extent possible and burn them. It has also been noted that application of 3 kg NPK/palm with 50 kg of green manure and 0.5 ton lime per acre also increased the yield of diseased palms. Intercropping with fodder and legumes under irrigated conditions have

also increased the yield.

248. RADHA, K. 1979. Possible involvement of biological agents in coconut root (wilt) disease. In: Symposium on Plantation Crops, 2nd, Ootacamund, Jun. 26-29, 1979. Proceedings of PLACROSYM II. Edited by C.S. Venkataram and others. p.316-324. (CPCRI Field Station, Trichur 680 121, Kerala).

Coconut root (wilt) disease is a complex malady. The disease is non-lethal, but debilitating. It occurs under varying ecological and soil conditions. Spread of the disease is also slow and erratic and is favoured by light soils and high water table. The disease syndrome consisting of rotting of roots, ribbing and marginal necrosis of leaflets and chlorosis of leaves is manifested in different combinations and intensities. Damage to the vascular tissues in the absorbing region of externally healthy roots of apparently healthy palms in the disease affected areas also occurs. A sap transmissible virus was suspected to be involved in the disease. *Rhizoctonia solani*, *R. bataticola*, *Fusarium equiseti*, *Cylindrocarpon effusum*, *Enterobacter sp.* and *Radopholus similis* have been found associated with affected roots. A critical assessment of the involvement of these soil borne pathogens in initiating the symptoms of the disease at the root level is attempted. The delay in symptom expression culminating in debilitation of the palm consequent on infection (s) is attributed to the massive root zone of the palm con-

249. RADHA, K. 1983. Occurrence of coconut root (wilt) disease in Northern Kerala and possible approach to control the disease. *Indian Cocon. J.* 13(9): 28-31. (CPCRI Field Station, Trichur, Kerala)

The distribution of the root (wilt) disease in the Northern Kerala since it first appeared is described. It occurs under varying situations. Until an effective control measure is evolved

the only possible solution is to carry out the eradication programme implemented by the CPCRI in 1979 with a view to contain the disease.

250. RADHA, K.; KOCHUBABU, M.; RETHINAM, P.; ANTONY, K.J. and SUKUMARAN, C.K. 1986. 'Contain' coconut root (wilt) disease by eradication of diseased palms. *Indian Cocon. J.* 16(6): 3-10 (CPCRI Field Station, Trichur, Kerala).

Large scale eradication of root (wilt) affected palms, was implemented in various districts of Kerala State, India and results had been tabulated. The disease was said to have been contained to a satisfactory level for some years.

251. RADHA, K.; RETHINAM, P. and KOCHUBABU, M. 1981. Northward march of coconut root (wilt) disease in Kerala. *Indian Cocon. J.* 12(3):1-4. (CPCRI Field Station, Trichur, Kerala).

A survey was conducted on the distribution of coconut root (wilt) disease in the southern part of Trichur district. The disease occurred in pockets and the early detection of the disease and prompt removal and destruction of the affected palms help in eradicating the disease and would stop from further spreading.

252. RAJAGOPAL, V.; CHEMPAKAM, B.; CECIL, S. ROBERT and KAMALAKSHY AMMA. P.G.

1982. Studies on phloem sap collection from healthy and root (wilt) diseased coconut palms. *Pl. Physiol. Biochem* 15: 308-312. (CPCRI, Kasaragod, Kerala).

Root (wilt) disease of coconut affected the rate of flow of vascular sap from the inflorescences. Healthy palms yielded sap for longer duration in large quantities while diseased palms had less sap flow for restricted period. Sap was analysed for pH, osmotic concentration and total sugars.

253. RAJGOPAL, V.; MATHEW, CHACKO; PATIL, K.D. and ABRAHAM, JOSE. 1986. Studies on water uptake by root (wilt) diseased coconut palms. *J. Plantn Crops* 14(1): 19-24. (CPCRI (RS), Kayangulam, Kerala).

Investigations were carried out to study the uptake of water by roots of apparently healthy and root (wilt) affected coconut palms (*Cocos nucifera* L.). Feeding the cut ends of roots with water indicated that diseased palms have lesser uptake than the healthy palms. Estimation of soil moisture content at different profiles in the basins of apparently healthy and diseased palms at one day interval for five days after irrigation indicated that the former had greater depletion of water than the latter. These results show that the root system of diseased palms is adversally affected.

254. RAJAGOPAL, V.; PATIL, K.D.; MATHEW, CHACKO and SUMATHYKUTTY AMMA, B. 1989. Physiological studies on root (wilt) diseased coconut palms under different management practices. *J. Plantn Crops* 16(Suppl.): 47-53. (CPCRI (RS), Kayangulam, Kerala).

Studies were undertaken in farmers' field on root (wilt) diseased coconut palms maintained under well managed, moderately managed and poorly managed conditions. Physiomorphological characters and disease index were recorded at half yearly intervals for five years.

Diseased palms responded markedly to good management as indicated by a decline in disease index (40% improvement over pretreatment conditions). The overall improvement was brought about by decrease in the intensity of flaccidity symptoms, enhanced greenness of leaves, reduction in leaf rot and necrosis and a fall in the rate of leaf senescence. There was only marginal improvement in palms under moderately managed conditions, while those under poor management had greater

tendency of deterioration. The efficacy of scientific management practices in root (wilt) affected gardens is highlighted.

255. RAJAGOPAL, V.; PATIL, K.D. and SUMATHYKUTTY AMMA, B. 1986. Abnormal stomatal opening in coconut palms affected with root(wilt) disease. *J. Exp. Bot.* 37(182): 1398-1405 (CPCRI (RS), Kayangulam, Kerala).

Root (wilt) diseased palms had lower stomatal resistance as compared to healthy palms, irrespective of age, season, levels of irrigation and period of observation. Thus, the stomatal regulation was significantly impaired in the diseased palms resulting in excessive water loss. Stomatal regulation in the case of other diseases caused by fungi, bacteria and MLO in different plants and in relation to toxins produced by such pathogens are discussed.

256. RAJAGOPAL, V.; PATIL, K.D. and SUMATHYKUTTY AMMA, B. 1984. *In vivo* nitrate reductase activity in the leaves of apparently healthy and root (wilt) diseased coconut palms. *In: Symposium on Plantation Crops, 6th, RRII, Kottayam, Dec 16-20, 1984.* Edited by M.R. Sethuraj and others. p.89-96. (CPCRI (RS), Kayangulam, Kerala).

The enzyme activity was more in the leaves of the middle whorl, followed by those of the outer whorl, than either in the spindle leaf or the first fully open leaf. In all the leaves studied, the diseased palms had higher activity than in the apparently healthy palms. The enzyme activity was influenced by the light intensity. Irrespective of the palm condition the NRA was higher at high light intensity (250 to 500  $\text{Em}^{-2} \text{s}^{-1}$ ) than that at low light intensity (250 to 500  $\text{Em}^{-2} \text{s}^{-1}$ ). Again the activity of enzyme in apparently healthy palms was less than in the diseased palms. With increase in the level of nitrogen application there was increase in NRA both in apparently healthy and diseased palms, the latter recording relatively

high activity. The response of palms to stimulated stresses indicated that the enzyme was adversely affected in both the palms. The study thus revealed disturbed nitrogen metabolism caused by the root (wilt) disease.

**257. RAJAGOPAL, V.; PATIL, K.D. and SUMATHYKUTTY AMMA, B. 1987.** Efficacy of management practices for increasing the productivity of root (wilt) affected coconut palms. *Indian Cocon. J.* **18(8):** 3-6. (CPCRI (RS), Kayangulam, Kerala).

Various methods of management practices responsible for improvement in diseased palms are discussed. Though the occurrence of the disease cannot be controlled, the overall yield potential of palms, particularly those in the early and middle stage of the disease can be enhanced by adopting scientific management practices. As fertiliser management alone proved to have limited success, in view of poor recovery in photosynthetic measures, the imposition of irrigation, wherever possible, may be implemented to exploit the yield potential of diseased palms. Adoption of package of practices by irrigation by even pot-watering for small land holdings would go a long way in alleviating the plight of coconut growers of affected districts.

**258. RAJAGOPAL, V.; SASIKALA, M.; SUMATHYKUTTY AMMA, B.; CHEMPAKAM, B. and RAWTHER, T.S.S. 1988.** Early diagnostic techniques on the root (wilt) disease of coconut in India. *Philipp. J. Cocon. Studies* **13(2):** 31-35 (CPCRI, Kasaragod, Kerala).

A comparative study was made between the serological test using the cross absorption technique and the physiological test based on stomatal resistance. Both tests could detect the disease 6 to 20 months prior to the manifestation of the visual symptom.

**259. RAJAGOPAL, V. and SUMATHYKUTTY AMMA, B. 1989.** Identification of root (wilt) diseased coconut palms before visual symptom

expression. *CORD5: 77-78.* (CPCRI, Kasaragod, Kerala).

Stomatal resistance ( $r_s$ ) and leaf water potential ( $\psi$ ) were employed as techniques to distinguish healthy and root (wilt) diseased coconut palms. Infected palms are characterised by low stomatal diffusive resistance and reduction in leaf water potential. A set of apparently healthy palms in root (wilt) affected areas when observed showed high  $r_s$  and high  $\psi$  in some of them. Such palms remained healthy while the others exhibited visual symptoms of the disease in 10-14 months.

**260. RAJAGOPAL, V.; SUMATHYKUTTY AMMA, B. and PATIL, K.D. 1987.** Water relations of coconut palms affected with root (wilt) disease. *New Phytol.* **105 (2):** 289-293. (CPCRI (RS), Kayangulam, Kerala).

Leaves of root (wilt) diseased coconut palms had lower stomatal resistance and leaf water potential than those of apparently healthy palms. Although there was a small reduction of osmotic potential in leaves of diseased palms, there was almost complete loss of turgor potential resulting in flaccidity.

**261. RAWTHER, T.S.S. and GOPINATHAN PILLAI, N. 1991.** Origin, distribution and production loss-coconut root (wilt) disease. In: Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. p.1-6. (CPCRI (RS), Kayangulam, Kerala).

Coconut root (wilt) disease is known to be present in South Kerala (India) since 1882. Now it is prevalent in the eight southern districts of Kerala in varying intensities ranging from 1.5 to 75.6%. Annual loss due to the malady is 968 million nuts. There is a significant negative correlation between yield and disease index of root (wilt) affected palms.

**262. RAY, P.K. 1980.** Application of nuclear techniques in the studies of root (wilt) disease

and nutritional problems of coconuts. *Indian Cocon. J.* 11(12): 8-10 (CPCRI (RS), Kayangulam, Kerala).

By using radioactive phosphorus and rubidium, it has been observed that palm injection technique is superior to soil application method with regard to absorption efficiency. Among plant injection techniques, feeding of  $^{32}\text{P}$  and  $^{86}\text{Rb}$  through cut end of roots has been found to be most efficient as compared to growing root-tip, leaf axil and stem injection methods. The results have shown that the active root zone is confined to 0.5 to 1.2 m lateral distance and to a slanting depth of 20 to 30 cm reaching up to the top surface of the roots.

263. RETHINAM, P. 1983. Problems of root (wilt) disease of coconut in Tamil Nadu. *Indian Cocon. J.* 13(9): 21-23. (CPCRI, Kasaragod, Kerala).

Root (wilt) disease, the major threat of the coconut plantations in Kerala have now been found in certain pockets of Tamil Nadu.

The article points out the need to take immediate action to stop spread of disease and to take up eradication of the disease. Suggestions and recommendations which would definitely prove to be successful in the eradication programme are indicated.

264. RETHINAM, P.; KOCHU KBABU, M. and RADHA, K. 1982. Coconut root (wilt) disease in Trichur district; observation on the distribution and intensity of the disease. *Indian Cocon. J.* 12(11): 11-15 (CPCRI Field Station, Trichur, Kerala).

This article describes the results of initial observation on the distribution and intensity of root (wilt) disease in Trichur district where the eradication programme was in progress to control the disease. Four hundred diseased palms were located in 209 gardens spread over

an area of about 20,000 ha in 8 villages. The highest incidence of disease was in the age group of 11-20 year. Disease incidence was less in more vigorous palms.

265. SADANANDAN, A.K., PILLAI, N.G. and CECIL, S. ROBERT. 1979. Effect of Agro-techniques on the root (wilt) disease of coconut. In: Symposium on Plantation Crops, 2nd, Ootacamund, Jun. 26-29, 1979. Proceedings of the PLACROSYM II. Edited by C.S. Venkataram and others. P.372-379. (CPCRI (RS), Kayangulam, Kerala).

The various agro-techniques including planting techniques, nutritional and irrigation requirements of palms, inter and mixed cropping in coconut garden, crop-live-stock-fisheries integration techniques etc. under the central and south Kerala conditons for containing the root (wilt) disease of coconut are discussed.

266. SAHASRANAMAN, K.N.; PILLAI, N.G.; JAYASANKAR, N.P.; POTTI, V.P.; VARKEY, THOMAS; KAMALAKSHY AMMA, P.G. and RADHA, K. 1983. Mixed farming in coconut gardens; economics and its effect on root (wilt) disease. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.160-63. (CPCRI (RS), Kayangulam, Kerala).

Effect of a mixed farming programme, consisting of cultivation of fodder grasses and legumes in the interspaces of coconut, maintaining milch cows, and recycling of cattle wastes, has been reported. Increase in nut yield, improvement of soil nutrient status and increased activity of beneficial micro organisms were observed in the experimental plots. In the root (wilt) disease affected gardens at Kayangulam foliar yellowing of palms was reduced but the treatment had no effect on the other symptoms on palms like flaccidity

and leaf necrosis. An evaluation of the economics of the practices, taking into account all the inputs and income from coconut and milk showed that mixed farming could increase per hectare income considerably. Employment potential also increased several fold due to introduction of this system in coconut gardens.

**267. SASIKALA, M. and GOPINATHAN PILLAI, N.** 1978. Transmission of coconut root (wilt) disease; reaction of 179 test plants. *J. Plantn Crops* 6(1): 17-20. (CPCRI (RS), Kayangulam, Kerala).

Experiments to study the transmission of coconut root (wilt) disease under normal environmental conditions, employing mechanical inoculation (with leaf and root extracts, partially purified preparations, root exudates and soil suspension) soil transmission, leachates and insect feeding were conducted on 22,160 plants of 170 species and cultivars belonging to 30 families. A few species of plants showed very low percentage of infection when mechanically inoculated with diseased leaf extracts. Plants which were earlier reported as suspect did not show any symptoms in these trials. Cowpea reported earlier as an indicator host also failed to show symptoms consistently.

**268. SASIKALA, M.; MATHEN, K.; GOVINDANKUTTY, M.P.; SOLOMON, J.J. and GEETHA, L.** 1988. Transmission of mycoplasma like organisms from *Cocos nucifera* with root (wilt) disease to *Catharanthus roseus* by *Cassytha filiformis*. *Neth. J. Plant. Path.* 94: 191-194. (CPCRI (RS), Kayangulam, Kerala).

A mycoplasma like organism (MLO) was successfully transmitted through dodder laurel (*Cassytha filiformis*) from root (wilt) diseased coconut to periwinkle (*Catharanthus roseus*) plants. Symptoms caused by the organism in periwinkle were chlorotic spots in the interveinal areas and at vein endings of fully opened leaves and premature leaf abscission. Light and electron-microscopic examination

revealed the presence of MLOs in diseased coconut palms, dodder laurel and periwinkle.

**269. SASIKALA, M.; SUMATHYKUTTY AMMA, B. and RAJAGOPAL, V.** 1991. Diagnosis. *In: Coconut root (wilt) disease.* Edited by M.K.Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. P.41-44. (CPCRI(RS), Kayangulam, Kerala).

A sero diagnostic test and a physiological test could be used to detect the root (wilt) diseased palms much before the visual symptoms appear. Serological test is used to determine the diseased palms with certainty irrespective of their age group and soil type. The antiserum is specific to root (wilt) disease and it does not react with samples of healthy palms and palms affected by other diseases. The test could detect root (wilt) affected palm 6 to 24 months prior to the manifestation of visual symptoms.

Physiological test based on determination of stomatal resistance and transpiration rate in the last fully opened leaf during the mid-day in the dry season could be used for distinguishing the diseased palms from the healthy ones. There was high stomatal resistance with correspondingly low transpiration rate in the apparently healthy palms whereas diseased palms exhibited low stomatal resistance and high transpiration rate. Measurement of leaf water potential could also be used as a diagnostic technique for early detection of the disease. Leaf water potential is lower in clearly diseased palms than in healthy ones.

**270. SETHUMADHAVA MENON, K. and RAMAKRISHNAN, NAYAR, T.V.** Effect of intercropping with tuber crops in root (wilt) affected coconut garden. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, 20-23 Mar. 1978.* Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p.416-424. (CPCRI (RS), Kayangulam, Kerala).

The effect of intercropping with tubers

like tapioca, elephant footyam, and yam on the yield and disease intensity of coconut palms in root (wilt) disease prevalent areas was studied for three years. Yield of coconut showed an improvement in the plot intercropped with elephant footyam, followed by yam to a lesser extent. In the plots with tapica as intercrop and in control plot, the intensity of root (wilt) disease was on the increase whereas in the the plots intercropped with yam and elephant foot yam a slight decline in severity of the disease was observed. Yield of tuber was highest in the case of tapioca. Growing all three intercrops was found profitable. The cost benefit analysis showed that coconut + tapioca combination gave the highest net return per rupee invested.

271. SOLOMON, J.J. and GOVINDANKUTTY, M.P. 1991. Etiology: Mycoplasma - like organisms. *In: Coconut root (wilt) disease*. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. p.31-40. (CPCRI (RS), Kayangulam, Kerala).

The presence of Mycoplasma like organisms was identified in sieve tubes of roots, tender stem, petiole and leaf bases of all the diseased palms examined as against their total absence in healthy palms. Transmission experiment in insect proof cages using healthy coconut seedlings showed that lace bug (*Stephanitis typica*) is the vector. MLO's were observed in brain and salivary glands of lace bug given a A+I period from 18 to 23 days. MLOs were also observed with salivary glands of plant hopper (*Proutista moesta*) with a A+I of 40 days. MLO's were transmitted from diseased coconut palms to periwinkle through dodder. Remission of symptoms of the disease also could be obtained by OTC treatment of diseased palms.

272. SOLOMON, J.J.; GOVINDAN KUTTY, M.P. and NIENHAUS, F. 1983. Association of mycoplasma like organisms with the coconut root

(wilt) disease in India. *Z. Pflkrankh. Pflschutz.* 90(3): 295-297. (CPCRI (RS), Kayangulam, Kerala).

Electron microscopic examination of ultra thin sections of tissue samples from root (wilt) disease affected coconut palms in India revealed the presence of mycoplasma like organisms (MLO) in the phloem elements. Presence of these structures within the apical meristem, petioles of very young leaves and root tips indicate that they are presumably associated with the disease.

273. SOLOMON, J.J. and SASIKALA, M. 1980. A serological appraisal of the connection of the Tobacco Mosaic Virus of coconut isolate with the root (wilt) disease of coconut. *Phytopath. Z.* 99: 26-32. (CPCRI (RS), Kayangulam, Kerala).

Highly sensitive and antiserum specific serological tests like double-diffusion plate method, immunoelectro-phoresis and immuno osmophoresis were used to determine association of TMV-Coconut isolate with the root (wilt) disease antigens. Similarly the root (wilt) antiserum reacted only against the root (wilt) diseased samples and not against the TMV antigens and healthy coconut samples. The specific reaction of each antiserum against its homologous antigens and no reaction against the heterologous antigens clearly proves that the TMV-Coconut isolate is not associated with the root (wilt) disease of coconuts.

274. SOLOMON, J.J.; SASIKALA, M. and SHANTA, P. 1983. A serological test for the detection of the root (wilt) disease of coconut. *In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976*, edited by N.M. Nayar, New Delhi: Wiley Eastern. p.401-405. (CPCRI, (RS), Kayangulam, Kerala).

Samples drawn from healthy and diseased palms of varying intensities and growing

Various soil types were tested with root (wilt) disease by the cross absorption technique. Of the 108 healthy samples from various parts of India gave negative reactions while 157 out of 161 diseased samples gave positive results.

**275. SOSAMMA, V.K. and KOSHY, P.K. 1991.** Etiology - C. Nematodes. In: Coconut root (wilt) disease. Edited by M.K. Nair and others. Kasaragod: CPCRI. Monograph Series no. 3. p.19-26. (CPCRI (RS), Kayangulam, Kerala).

Widespread occurrence of the burrowing nematode, *Radopholus similis* on coconut was noticed in Kerala, Karnataka and Tamil Nadu. *R. similis* infestation produces small, elongated, orange coloured lesions on tender, creamy white roots. These lesions enlarge and coalesce to cause extensive rotting of roots. The coconut isolate of *R. similis* was identified as the "banana race" with a haploid chromosome number of 4 ( $n=4$ ). *R. similis* has a wide host range of about 375 species of plants, the coconut isolate has 48 species. In Kerala, maximum *R. similis* population in coconut roots was found to occur during October to November and minimum or nil during March to July. The pathogenic effect of *R. similis* on coconut seedlings were studied. The pathogenic threshold level of *R. similis* is 1000 nematodes per seedling (one nematode per 10 cm<sup>3</sup> of sandy loam soil) under greenhouse conditions. Thirty per cent increase in yield and 5 to 10 percent decrease in disease index of palms affected with root (wilt) disease has been recorded by the application of *Hydnocarpus* oil cake @ 4 kg per palm as well as with phorate @ 10 g a.i./palm in June-July and October-November.

**276. SUMATHYKUTTY AMMA, B. and PATIL, K.D. 1984.** Pectin lyase activity in the roots of root (wilt) disease affected coconut palm; a short scientific note. *J. Plantn Crops* 12(2): 182-184. (CPCRI (RS), Kayangulam, Kerala).

Results of an experiment carried out to ascertain the role of pectinolytic enzymes in the degradation of root tissues affected by root (wilt) disease, revealed that pectin lyase activity in the decayed roots of root (wilt) diseased palms was 20.60 and 3.40 in decayed roots of healthy palms. Pectin lyase activity was not detectable in healthy roots. Whether this enzyme is a host specific one or a pathogen specific one could not be demonstrated.

**277. SUMATHYKUTTY AMMA, B. and PATIL, K.D. 1986.** An attempt to regenerate roots in root (wilt) affected coconut palms with phenols, hormones and amino acids. In: Workshop on Special Problems in Physiological Investigation of Tree Crops, *RRII, Kottayam, Aug. 26-28, 1982*. Proceedings of workshop. p.55-58. (CPCRI (RS), Kayangulam, Kerala).

Growth hormones like IBA and NAA, phenols and amino acids in different concentrations singly and in combinations were applied by the lanoteric paste method to the stem base in root (wilt) diseased palms. Root initiation was observed between six months to one year after treatment. IBA 500 ppm + phenols 400 ppm produced the maximum number of roots, followed by NAA 500 ppm and glutamic acid 500 ppm.

**278. THAMPAN, P.K. 1983.** The strategy of coconut development in root (wilt) affected coconut tracts in Kerala State. *Indian Cocon. J.* 13(9): 12-14. (Coconut Development Board, Cochin, Kerala).

The onslaught of the root (wilt) disease has already disrupted the economic stability of the coconut growers in the state. Research findings and practical experience have shown that even the small holdings which are within the grip of the devastating root (wilt) disease could be rehabilitated into viable farming units through the adoption of a sound management strategy. Maintenance of optimum population

of productive palms per unit area, use of precocious and high yielding planting material and the introduction of integrated farming system in coconut holdings will constitute the essential features of such a strategy.

**279. THAMPAN, P.K. and MARKOSE, V.T. 1977.** Neo-rhizosphere technique a promising line of study to rejuvenate root (wilt) affected palms. *Cocon. Bull.* 7(9): 1-3. (Coconut Development Board, Cochin, Kerala).

With the emergence of new root system in badly diseased palms, foliar symptom associated with root (wilt) were reversed. The results of the trial also indicate that better drainage, aeration and use of organic manures and fertilizer in a fresh rhizosphere above the bole region are effective in producing fresh root system which could reverse the specific symptoms associated with coconut root (wilt) disease.

**280. THOMAS, GEORGE, V. 1988.** Vesicular-arbuscular mycorrhizal symbiosis in coconut (*Cocos nucifera* L.) in relation to the root (wilt) disease and intercropping or mixed cropping. *Indian J. agric. Sci.* 57(2): 145-147. (CPCRI (RS), Kayangulam, Kerala).

Studies on root (wilt) diseased and apparently healthy coconut palms revealed the adverse effect of root (wilt) disease on the incidence of VAM in coconut. The population of VAM spores in the root region soil and the extent of root colonization were less in diseased palms when compared to that in the healthy ones. In order to study the effect of crop mixing on VAM symbiosis, mycorrhizal status of the component crops in coconut-cacao mixed cropping and coconut-hybrid napier intercropping (mixed farming) experiments was determined. Mycorrhizal spore counts were more in the mixed farming plots. The spore populations were 72.3% less at 25-50 cm depth and 83.5% less at 50-100 cm depth in coconut

basins than at 0-25 cm layer. Basin cropping with *Pueraria phaseoloides*, *Calopogonium mucunoides* and *Mimosa invisa* was also effective in augmenting endomycorrhizal symbiosis in coconut.

**281. THOMAS, GEORGE V. and GEORGE, MATHEW. 1990.** Basin management using green manure legumes for root (wilt) affected coconut palms. *Indian Cocon. J.* 20(11): 7-8. (CPCRI, Kasaragod, Kerala).

*Pueraria phaseoloides*, *Mimosa invisa* and *Calopogonium mucunoides* were found to be the suitable legumes for basin management of coconut. The basin cultivation and incorporation of these green manure legumes were effective in increasing the yield of root (wilt) affected palms without causing further deterioration in the disease condition. This technique can therefore form a component in the management programme for root (wilt) affected coconut gardens.

**282. VARADARAJAN NAIR, P. and RAJAN, K.M. 1978.** Reaction of different coconut hybrids to root (wilt) disease. *Indian Cocon. J.* 9(6): 9. (Rice Res. Station, KAU, Moncompu, Alleppey, Kerala).

In a study to find out the relative tolerance of different coconut hybrids to root (wilt) disease from nine hybrids tested; except Tall x Gangabondam and susceptible check, WCT, disease index was less than 10% (not diseased) in other hybrids. In the crosses of Yellow Dwarf x Laccadive Ordinary and Tall x Nyiar Gading all the seedlings planted have survived. The survival percentage in T x D (20%) and TxLO (40%) was poor due to the attack of rhinoceros beetle. Crosses YD x LD and T x NYG seem to perform better than other crosses. Further investigations are necessary to confirm the results.

**283. VARKEY, THOMAS.; KAMALAKSHY AMMA, P.G.; RAMANANDAN, P.L. and NAMBIAR, P.T.N.**

Foliar yellowing of coconut palms in healthy and root (wilt) affected areas. *J. Plantn Crops* 7(2): 117-120. (CPCRI (RS), Kayangulam, Kerala).

An attempt had been made to check the foliar yellowing by applying different nutrients and to study its effect on growth and yield palms. Foliar sprays with 2%  $MgSO_4$  and 1%  $FeSO_4$  and basal application  $MgSO_4$  reduced foliar yellowing by 26% in diseased palms and 87% in healthy palms. In diseased palms the applications increased yield by 106%, while in healthy palms, the increase was 95%.

284. WAHID, P.A.; KAMALAM, N.V. and VENUGOPAL, V.K. 1983. X-Ray fluorescence spectra of root (wilt) affected coconut palm. *J. Plantn Crops* 11(2): 91-100. (College of Horticulture, KAU, Trichur, Kerala).

Trace elements composition of soils, root and leaf samples collected from healthy, and root (wilt) diseased coconut palms was determined employing energy dispersive X-ray fluorescence technique. Non-nutrient trace elements such as Ti, Cr, Ni, Pb, Br, Rb, Sc and Zr were detected in soil samples. Sandy soil in the Kayangulam area is rich in Ti. Strontium content of laterite soils of Pilicode is less as compared to similar soils in the diseased tract.

Root samples contain all these elements except Cr and Zr in detectable concentrations. Ni content of roots from diseased palms were higher than that of roots from healthy palms. Low concentration of Sr in the leaves of diseased palms and relatively higher concentration of this element in the roots indicated that the translocation of Sr in diseased palms is hindered. Ti, Cr, Pb and Zr were not detectable in coconut leaves.

285. WAHID, P.A. and KAMALAM, N.V. 1988. Nutrient distribution in the crown of healthy and root (wilt) affected coconut palms. *Indian Cocon. J.* 18(11): 8-12 (College of Horticulture, KAU, Trichur, Kerala).

The pattern of distribution of nutrients in the crown of the coconut palms as influenced by root (wilt) disease was studied to examine whether 14th leaf is suitable for comparison of nutrient status between healthy and diseased palms. The result indicated that the nutrient levels in the leaves of diseased palms are generally higher than the healthy ones. The differences in foliar levels of nutrients are more conspicuous for leaf ranks 4 and 6. The 14th leaf which is generally considered as the index for nutrient deficiency diagnosis in coconut is not suitable for comparison of the nutritional status of healthy and root (wilt) affected palms.

## 4.2 Other Diseases

286. AGRICULTURAL COLLEGE and RESEARCH INSTITUTE (TNAU), MADURAI. 1983. Coconut disease management through chemicals. *In: National Seminar on Management of Crop Disease of Oilseed Crops, Agric. College and Res. Institute, TNAU, Madurai, Jan. 21-22, 1988.* Edited by P. Narayanasamy. p.95-105. (Agr. College and Research Institute, TNAU, Madurai, T.N.).

Thanjavur wilt of coconut is the major disease of coconut, limiting coconut production in Tamil Nadu, *Ganoderma lucidum* (Leys) Korst is found associated with the disease in most of the cases and is considered as the main causal agent of the disease. Heavy dose of fertilizer increased the wilt disease. The present experiment was designed to find out the effects of fertilizer and organic manure on development of wilt disease and yield and the results are reported.

287. ANBALAGAN, M.; SHANMUGAM, R.; BHASKARAN, R. and VIJAYARAGHAVAN, H. 1987. Biochemical constituents of coconut palms as influenced by Thanjavur wilt disease. *In: International Symposium on Ganoderma Wilt Diseases on Palms and Other Perennial Crops, Soil and Water Management Research Institute, Thanjavur, Jan. 6-8, 1987.* p.17-18. (Abstract) (RARS, TNAU, Veppankulam, 614 066, T.N.).

Changes in the biochemical constituents *viz.*, minerals, carbohydrates and phenols in the stem, bole and root tissues of healthy and Thanjavur wilt affected coconut palms have been reported. Effect of tapping the diseased palms for 'neera' production on phenol and sugar content in the leaves and the disease intensity have been compared with diseased untapped palms.

288. ANILKUMAR and NAMBIAR, K.K.N. 1991.

An improved method for isolation of *Thielaviopsis paradoxa* from stem bleeding affected coconut palm. *CORD* 7(1): 49-53. (CPCRI, Kasaragod, Kerala)

An improved method for isolation of *T. paradoxa* from infected stem has been described. This method involved inoculating infected stem tissues on coconut leaf frond by bore-hole method. Inoculating at 30°C in polythene bags for ten days and reisolation of the fungus from the margin of rotten frond tissues on sugarcane juice agar. Very high percentage recovery of the fungus (98.3%) was obtained by this method.

289. BHASKARAN, R. 1986. Coconut disease and their management. *In: Pest and disease management; oil seeds and pulses, millets and cotton.* Edited by S. Jayaraj. Coimbatore. Tamil Nadu Agricultural University. p.81-89. (Coconut Res. Station, TNAU, Veppankulam 614906, T.N.).

Symptoms, epidemiology, etiology and management of *Ganoderma* wilt, root (wilt), bud rot, grey leaf spot, stem bleeding and pencil point diseases of coconut have been described.

290. BHASKARAN, R.; CHANDRASEKAR, G. and JAGANNATHAN, T. 1978. Control of Thanjavur wilt disease of coconut. *Fmg Agric.* 10(4): 115-116. (Cocon. Res. Station, TNAU, Veppankulam 614906, T.N.)

To determine whether the disease intensity could be checked by maintaining the soil moisture at optimum level along with other control measures a field experiment was conducted and the results have been presented.

291. BHASKARAN, R.; CHANDRASEKHAR, G. and PETER, S.D. 1979. Control of pencil point disease of coconut. *Indian Cocon. J.* 10(7): 1-

2. (Cocon. Res. Station, TNAU, Veppankulam, 614906, T.N.).

Of the nine different treatments tried, including applications of major and minor nutrients and/or fungicides, the best results with regard to stem girth increment, number of green leaves and nut yield were obtained from palms receiving NPK + minor nutrients (B, Cu, Zn, Fe, Mn and Mo). NPK alone gave inferior results.

292. BHASKARAN, R.; CHANDRASEKAR, G. and RAMANATHAN, T. 1984. Survey and epidemiology of Thanjavur wilt of coconut. *In: All India Symposium on Coconut Diseases, RARS, TNAU, Veppankulam, 1984. Proceedings of symposium. Edited by M. Balasubramanian and others. p.14-18 (RARS, TNAU, Veppankulam, T.N.).*

Results of the survey on the incidence of Thanjavur wilt of coconut in the different districts of Tamil Nadu and epidemiology of the disease have been described. The disease incidence was highest in Thanjavur district (4.9%) followed by Chingleput district (4.5%). The disease incidence was more between the months of March and August. Positive correlation was observed between mean maximum temperature and the number of bleeding palms.

293. BHASKARAN, R.; CHANDRASEKAR, G. and SHANMUGAM, N. 1985. Problems and priorities in the management of Thanjavur wilt of coconut. *In: Integrated pest and disease management; proceedings of the national seminar. Edited by S. Jayaraj. Coimbatore: Tamil Nadu Agricultural University. p.183-187. (Cocon. Res. Station, TNAU, Veppankulam, T.N.).*

Distribution of Thanjavur wilt of coconut in Tamil Nadu, etiology, epidemiology and management of the disease have been described. Future thrust areas of research on this disease

have been indicated.

294. BHASKARAN, R.; JAGANATHAN, T. and CHANDRASEKAR, G. 1978. Effect of fertilizers on Thanjavur wilt of coconut. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar.20-23, 1978. Proceedings of PLACROSYMI. Edited by E.V.Nelliath and others. p.351-353. (Coconut Res. Station, TNAU, Veppankulam, T.N.).*

The disease intensity in Thanjavur wilt affected coconut palms was aggravated by the application of heavy doses of fertilizers viz., 0.7kg N, 0.5kg P<sub>2</sub>O<sub>5</sub> and 1.8kg K<sub>2</sub>O/palm/year. The apparently healthy palms showed stem bleeding after six months of applying the heavy dose and the intensity of the disease increased steadily. Application of 0.50 or 0.75kg P<sub>2</sub>O<sub>5</sub> with 0.35kg N and 0.45kg K<sub>2</sub>O/palm/year did not show any adverse effect.

295. BHASKARAN, R.; JAGANNATHAN, T. and CHANDRASEKAR, G. 1978. Role of micronutrients and fertilizers in pencil point disease of coconut. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings PLACROSYM I. Edited by E. V. Nelliath and others. p.354-359. (Coconut Res. Station, TNAU, Veppankulam, T. N.).*

Low level of nitrogen and phosphorus was observed in soil samples collected at different depths from areas where coconut palms exhibited pencil point disease symptoms. Among the micronutrients, iron and manganese content were low. Application of micronutrients along with fertilizers increased the girth of the palm and the number of spathes produced.

296. BHASKARAN, R.; RAMADOSS, N. and RAMACHANDRAN, T. 1987. Plant extracts on the growth of *Ganoderma lucidum*. *Tamil Nadu Agric. Univ. Newsletter* 17 (7): 2. (Coconut Res. Station, TNAU, Veppankulam 614906, T.N.)

Among the various plant extracts tested,

banana rhizome extract and 'Kolingi' root extract were highly inhibitory to the growth of *Ganoderma lucidum* giving 1.2 cm and 4.00 cm radial growth respectively as against 8.6 cm growth in potato dextrose agar medium without plant extracts.

297. BHASKARAN, R.; RAMADOSS, N. and RAMACHANDRAN, T.K. 1988. Biological control of Thanjavur wilt disease of coconut. *Indian Cocon. J.* 19(6): 3-8. (Coconut Res. Station, TNAU, Veppankulam-614906, T.N.).

*Trichoderma harzianum* and two isolates of *T. viride* were found to be antagonistic to *Ganoderma lucidum* (Leys) Karst., the fungus associated with Thanjavur wilt of coconut. *T. harzianum* lysed the hyphae of *G. lucidum* while the two isolates of *T. viride* besides lysis also punctured the host hyphae, thus causing physical parasitism also. Neem cake extract completely inhibited the growth of *G. lucidum* and the extracts from banana rhizome and 'Kolingi' roots also inhibited the growth significantly. Neem cake encouraged the population of saprophytic soil microflora especially *Trichoderma* and was effective in the control of Thanjavur wilt disease.

298. BHASKARAN, R.; RAMADOSS, N. and SURIACHANDRASELVAN, M. 1988. Effect of plant extracts on the growth of *Ganoderma* spp. associated with Thanjavur wilt disease of coconut. In: National Seminar on Management of Crop Disease with Plant Products and Biological Agents, *Agricultural College and Research Institute, TNAU, Madurai, 1988*. Abstracts of papers. p.24. (Coconut Res. Station, TNAU, Veppankulam 614906, T.N.).

Effect of plant extracts on mycelial growth of *Ganoderma applanatum* and *G. lucidum* has been reported. Banana rhizome extract inhibited the growth of *G. lucidum* by 86% and 'Kolingi' root extract gave 54% inhibition.

299. BHASKARAN, R. and RAMANATHAN, T.

1980. Control of Thanjavur wilt of coconut. *Tamil Nadu Agric. Univ. Newsletter* 10(6): 3-4. (Coconut Res. Station, TNAU, Veppankulam, T.N.)

Bordeaux mixture soil drenching, aureofungin-sol stem injection and neem cake application are effective for the control of Thanjavur wilt of coconut.

300. BHASKARAN, R. and RAMANATHAN, T. 1982. Management of Thanjavur wilt of coconut. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18 1982. Proceedings PLACROSYM V. Edited by K.V.A. Bavappa and others. p.521-526. (Coconut Res. Station, Veppankulam, 614906, T.N.).

It was found that for containing Thanjavur wilt disease the soil organic matter level should be increased by the application of organics such as farm yard manure, tank silt or neem cake. Neem cake applied to the soil at the rate of 5 kg/palm/year was effective in keeping the disease under control to a great extent and giving regular irrigation to the diseased palms during summer helped in maintaining the vigour of palms. Among the fungicides tried, soil drenching with 40 liters of 1% Bordeaux mixture combined with stem injection of auriofungin-sol was very effective in containing the disease. Palms given this treatment thrice at quarterly intervals gave economic yields for three to four years with reduced disease intensity.

301. BHASKARAN, R. and RAMANATHAN, T. 1982. Management of wilt affect coconut. *Tamil Nadu Agric. Univ. Newsletter* 12(2): 1. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Control measures to contain the Thanjavur wilt of coconut are briefly described.

302. BHASKARAN, R. and RAMANATHAN, T. 1983. Role of fertilizers and organic manures on Thanjavur wilt of coconut. *Indian Cocon.*

J. 14(3): 7-9. (Coconut Res. Station, TNAU, Veppankulam, 614906, Thanjavur, T.N.).

It is observed that Thanjavur wilt disease caused by the fungus *Ganoderma lucidum* increased with high doses of fertilizer. Since fertilizing palm is essential for good production, experiments were designed to find out the optimum fertilizer dose for wilt affected palms that would give increased yields while not increasing the disease situation. Also effect of various organic manures combined with Bordeaux mixture soil drenching in the control of the disease is studied.

303. BHASKARAN, R. and RAMANATHAN, T. 1983. Variability of coconut varieties and hybrids to natural infection of grey blight disease. *Madras Agric. J.* 70(10): 685-686. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Twenty eight varieties and four hybrids were screened for grey blight disease of coconut. Among the hybrids, East Coast Tall x Dwarf Green had a fairly low disease index of 17.0 as against 21.9 in East Coast Tall. Among the varieties, Chowghat Dwarf Orange, Dwarf Green, San Blas and Laccadive Micro showed relatively less incidence of grey blight.

304. BHASKARAN, R. and RAMANATHAN, T. 1984. Occurrence and spread of Thanjavur wilt disease of coconut. *Indian Cocon. J.* 15(6): 12-14. (Dept. of Plant Pathology, TNAU, Coimbatore, T.N.).

To assess the incidence and severity of the Thanjavur wilt disease, meteorological data such as maximum and minimum temperature, rainfall and humidity were recorded. It was observed that the mean incidence in Thanjavur Dt. was as high as 8.35% - 31.40% between the months of March and August.

Correlation studies with different weather factors revealed that there is no correlation between mean minimum temperature, rainfall

and humidity. But positive correlation was observed with mean maximum temperature. Further studies revealed that though fresh infection is high between March and August, further development of disease symptoms in the diseased palms has no correlation with weather factors.

305. BHASKARAN, R.; RAMANATHAN, T. and RAMIAH, M. 1982. The Thanjavur wilt. *Intensive Agric.* 20(9 & 10): 19-21. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Symptoms of Thanjavur wilt and its spread and management have been described.

306. BHASKARAN, R.; RAMANATHAN, T. and RAMIAH, M. 1984. Thanjavur wilt of coconut; its occurrence, spread and management. In: Symposium on Plantation Crops, 6th, RRII, Kottayam, Dec. 16-20, 1984. Proceedings of PLACROSYM VI. Edited by M.R. Sethuraj and others. p.107-113. (Coconut Res. Station, TNAU, Veppankulam 614906, T.N.).

Occurrence of Thanjavur wilt in different districts in Tamil Nadu, spread of the disease and management of the disease by micro-nutrients, fungicides, organic manures and soil moisture conservation methods have been reported.

307. BHASKARAN, R. and RAMIAH, M. 1984. Chemical control of Thanjavur wilt of coconut. In: All India Symposium on Coconut Diseases, RARS, TNAU, Veppankulam, 1984. Proceedings of symposium. Edited by M. Balasubramanian. p.22-24. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Combined treatment of Aureofungin-sol stem injection + Bordeaux mixture soil drenching (AF + BM) as well as the treatment AF + BM + neem cake were very effective in the control of Thanjavur wilt of coconut.

308. BHASKARAN, R.; RETHINAM, P. and NAMBIAR, K.K.N. 1989. Thanjavur wilt of

coconut. *J. Plantn Crops* 17(2): 69-79. (Cocon. Res. Station, TNAU, Veppankulam 614906, T.N.)

Information available on the occurrence and spread of Thanjavur wilt in Tamil Nadu, symptoms, etiology and epidemiology of the disease, physiology of diseased palms, methods for early detection and management of the disease have been reviewed.

309. BHASKARAN, R.; SURIACHANDRASELVAN, M. and RAMACHANDRAN, T. K. 1990. Ganoderma wilt disease of coconut; a threat to coconut cultivation in India. *Planter* 66(774): 467-471. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Symptoms of Ganoderma wilt disease of coconut (also called Thanjavur wilt) prevalent in India, are described. *Ganoderma lucidum* was isolated from the roots of diseased palms which after artificial inoculation caused root rot in healthy coconuts. An increase in soil temperature increased the severity of the disease and an increase in soil moisture decreased the severity. Incorporation of organic manure in the soil in coconut basins (especially neem cake) and irrigation during the summer months reduced the severity of the disease. Soil drenching with 1 percent Bordeaux mixture and root feeding with 2 g of Aureofungin-sol with 1 g of copper sulphate in 100 ml of water, both done 3 times at quarterly intervals preferably during July, October and January were very effective in controlling the disease.

310. BHASKARAN, R.; SURIACHANDRASELVAN, M. and RAMADOSS, N. 1988. Problems and priorities in the management of Thanjavur wilt of coconut. In: Symposium on Plantation Crops, 8th, Kochi, Dec. 28-30, 1988. In: Abstracts of PLACROSYM VIII. p.30-41. (Cocon. Res. Station, TNAU, Veppankulam 614906, T.N.).

Results of the field experiments conducted on various management practices for Thanjavur wilt have been summarised. The future thrust

areas of research have been listed.

311. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD. 1980. Coconut crown choke disease, a survey report. Kasaragod: CPCRI. 15p.

This report presents the results of a survey conducted in Assam on the incidence of crown choke disease of coconut. Maximum disease incidence was noticed in Kamrup district (14.4%) while the average disease incidence in the five districts surveyed was 10.8%. The total loss in yield due to the disease was estimated 6.38 million nuts.

312. DAS, C.M. and MAHATA, I.C. 1985. Evaluation of some fungicides against *Pestalotia palmarum* Cke, incidence of grey blight of coconut. *Pesticides* 19(5): 37-39. (Dept. Mycology and Plant Pathology, OUAT, Bhubaneswar 751003, Orissa).

Fourteen fungicides were tested in vitro for their relative efficacy in controlling the grey blight of coconut, caused by *Pestalotia palmarum*. Bavistin, hexathir and tecto-60 completely inhibited the growth of *P. palmarum* in all the concentrations (100,200,300,400 and 500 ppm.). The growth of the fungus was also completely inhibited by brestan-60 (Fentin acetate) at 300,400 and 500 ppm, Captan at 400 and 500 ppm as well as difolatan 80 w and Dithane M 45 (Mancozeb) at 500ppm.

313. DAS, C.M.; MISHRA, S.K. and SWAIN, P. 1985. Effect of different sources of carbon and nitrogen on the growth and sporulation of *Pestalotia palmarum* Cke., causing grey blight of coconut. *Indian J. Mycol. Pl. Pathol.* 15(3): 325-327 (Dept. of Plant Pathology, OUAT, Bhubaneswar 751003, Orissa).

Sucrose was the best carbohydrate for growth of *P. palmarum* while lactose and glucose gave maximum sporulation. Peptone was the

best N source, followed by ammonium oxalate.

314. DAS, T.P.M. and CHEERAN, A. 1986. Infectivity of *Phytophthora* species on cash crops in Kerala (Mal.) *Agric. Res. J. Kerala* 24(1): 7-13. (College of Horticulture, KAU, Trichur 680654, Kerala).

The *Phytophthora* isolates from *Piper nigrum*, arecanut, rubber, cocoa, coconut and cardamom (*Elettaria cardamomum*) exhibited similar morphological characters and were identified as *P. palmivora*. Only cardamom and rubber isolates produced sexual structures on culture media. Cross inoculation tests with all these isolates were successful.

315. DUTTARAY, S.; POI, A.K. and KAISER, S.A.K.M. 1989. Occurrence of *Ganoderma lucidum* (Leys.) Karst. causing anabe-roga of coconut palm in West Bengal. *Environ. Ecol.* 7(2): 492-493. (Dept. of Plant Pathology, BCKVV, Kalyani 741235, W.B.).

Incidence of *Ganoderma lucidum* causing anabe-roga of coconut palm has been reported from the Indogangetic plains of West Bengal. The fungus also showed its pathogenicity when tested on acid lime.

316. GEORGE and RAJEEV, P. 1986. Bud rot of coconut palm; a disease caused by phycomycetes. *Indian Cocon. J.* 17(4): 13 (Coconut Development Board Regional Centre, Patna, Orissa).

A brief account on bud rot disease caused by *Phytophthora palmivora* has been presented. Symptoms, causative organism, spread of disease and its control have been included in the description.

317. GOVINDAN, M.; RADHAKRISHNAN, T.C. and SATHIARAJAN, P.K. 1988. Reaction of certain varieties and hybrids of coconut to natural infection of leaf blight caused by *Pestalotia elaeidis* (Booth & Robertson) Van Der AA. In:

National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur Nov. 23-26, 1988. Abstracts of papers. p.17. (RARS, KAU, Pilicode 670353, Kerala).

Leaf blight of coconut caused by *Pestalotia elaeidis* is found to occur in very severe manner in certain parts of Kerala. Hence a study was undertaken to determine whether there is any genetic source of resistance or tolerance among different cultivars and hybrids of coconut. Eight varieties and 12 hybrids grown in the coconut grove at the Regional Agricultural Research Station, Pilicode were selected for the study. None of the varieties or hybrids is immune to this disease. However, MDY had less disease incidence followed by CDG. In both these varieties the area of leaf infection recorded also was low.

318. GOVINDU, H.C.; RAO, A.N.S. and MURTHY K.V. KESHAVA. 1983. Biology of *Ganoderma lucidum* (Leys) Karst and control of anabe roga of coconut. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. p.325-332. (Dept. of Plant Pathology, UAS, Hebal, Bangalore, Karnataka).

*Ganoderma lucidum* (Leys) Karst, causes anabe roga (mushroom disease) in Karnataka. It is widely present in the maidan parts especially in sandy-soils of the southern region of the State. This disease seems to affect older palms in neglected gardens more than the young palms. The pathogen has a wide host range. Some of the important hosts are *Areca catechu*, *Mangifera indica*, *Atrocarpus integrifolia*, *Cassia siamea*, *Pongamia glabra*, *Dalbergia sissoo*, *Morus alba*, *Acacia* sp., *Delonix regia* and *Citrus* sp. (especially acid lime)

The disease manifests itself in various forms presenting different symptoms at various stages of growth of the coconut palm. The

three characteristic symptoms are: the outer whorl of leaves droop down, become yellowish and reduced in size and ultimately dry up; the stem shows a characteristic oozing of brownish gummy substance through cracks and wounds on the lower parts; later in disease symptomatology, fructifications occur in the form of corky brackets of the fungus at the lower part of the trunk. The ultimate result is the death of the palm. The seat of infection is the base of trunk and roots. Interior of the affected stems become dark brown 50–70 cm from the base and emits musty smell. The anabe roga in coconut is controlled by biological, cultural, and chemical methods. A new coded antibiotic gave good control at a concentration of 7.5 g/10 litre water, when applied at the basal portion of the palm through a bore.

319. GOWDA, P.V. 1987. *In vitro* studies on the interaction of antagonistic mycoflora with *Thielaviopsis paradoxa*, the causal agent of coconut stem bleeding disease. M.Phil. dissertation. Mangalore University, Mangalore. 215p. (CPCRI, Kasaragod, Kerala).

Studies on the effect and growth of six isolates of *T. paradoxa* from different localities on various culture media showed that dextrose asparagine phosphate agar and kirchoff's agar supported maximum growth. Bark and soil samples from neem cake ammended diseased plots showed higher population of *Trichoderma harzianum*, *Aspergillus niger* and *Penicillium* sp. *In vitro* interaction studies revealed that *Trichoderma viride* exerted maximum inhibition on *T. paradoxa* (90%) followed by *T. harzianum* (86.6%) and *A. niger* (50%).

320. GOWDA, P.V. and NAMBIAR, K.K.N. 1990. Variation in cultural characters among isolates of *Thielaviopsis pardoxa*, casual agent of stem bleeding disease of coconut. In: Symposium on Plantation Crops, 9th, CCRI, Chikmagalur, Dec. 5–7, 1990. Abstracts of papers. p.18–

19. (CPCRI, Kasaragod, Kerala).

Stem bleeding disease is one of the disease of coconut reported from all coconut growing regions. The fungus multiplied in the infected stem tissues and soil debris and produced endoconidia and/or chlamydo spores. Variations in cultural, morphological and spore production characters of five different isolates of *T. paradoxa* are reported.

321. GOWDA, P.V. and NAMBIAR, K.K.N. 1991. *In vitro* interaction of antagonistic fungi with *Thielaviopsis paradoxa*, the pathogen of coconut stem bleeding disease. *J. Plantn Crops* 18(suppl.): 233–238. (CPCRI, Kasaragod, Kerala).

*In vitro* interaction of three antagonistic fungi, viz., *Aspergillus niger*, *Trichoderma harzianum* and *T. viride* with four isolates of *Thielaviopsis paradoxa* (de Seynes) von Hohnel, the causal agent of stem bleeding disease of coconut was studied. Three methods of inoculation, viz., (1) *T. paradoxa* inoculated 12 hours before the inoculation of antagonistic fungus; (2) both *T. paradoxa* and antagonistic fungus were simultaneously inoculated, and (3) *T. paradoxa* inoculated 12 hours after the inoculation of the antagonistic fungus were tested. Minimum growth inhibition of different isolates of *T. paradoxa* was observed when *T. paradoxa* was inoculated 12 h before the inoculation of the antagonist and maximum growth inhibition of *T. paradoxa* was observed when *T. paradoxa* was inoculated 12 h after the inoculation of the antagonistic fungus. Among the three antagonistic fungi tested, an isolate of *Trichoderma viride* exerted maximum growth inhibition (90%) of the pathogen.

322. GUNASEKARAN, M.; RAMADOSS, N.; RAMIAH, M.; BHASKARAN, R. and RAMANATHAN, T. 1986. Role of neem cake in the control of Thanjavur wilt of coconut. *Indian Cocon. J.* 17(1): 7–12 (Coconut Res.

Station, TNAU, Veppankulam, T.N.).

Application of neem cake increased the total population of fungi in the rhizosphere region of coconut palm. Under *in vitro* conditions, growth of *Ganoderma lucidum* in neem cake incorporated potato dextrose agar medium was completely inhibited. Neem cake treatment was as effective as the combined treatment of aureofungin-sol + Bordeaux mixture + neem cake.

323. JADEJA, K.B.; SARVAIYA, A.J. PATEL and KAPADIA, M.N. 1986. A survey of important diseases of coconut palm in Gujarat State. *Indian Cocon. J.* 17(4): 5-9. (Dept. of Entomology, College of Agric., GAU, Junagadh, 36200, Gujarat).

A survey of incidence of coconut diseases in Gujarat was carried out in 1983-84. Bud rot and stem bleeding were observed in maximum number of palms, and an unknown (wilt) was noted only in some spots.

324. JAGANATHAN, T. and RAMASAMI, R. 1977. Pencil point disease of coconut in Tamil Nadu. *Indian Cocon. J.* 8(6): 3-5, 10 (Cocon. Wilt Disease Scheme, TNAU, Muthupet 614704, T.N.).

Effects of the disorder on palms in five affected plantations are described. No pathogenic organism or insect was found to be associated with the disorder, and the symptoms did not resemble any of the established virus diseases. Occurrence of the disorder was associated with deficiency of nutrients, particularly N and P. Morphological changes caused by the disorder are discussed.

325. JAYARAJ, S.; RANGARAJAN, A.V.; JEYARAJAN, R. and BHASKARAN, R. 1986. Pest and disease surveillance in coconut. *In: Pest and disease management; oilseeds, pulses, millets and cotton.* Coimbatore, Tamil Nadu Agricultural University. Edited by S. Jayaraj.

p.81-89. (Centre for Plant Protection Studies, TNAU, Coimbatore, T.N.).

Methodology for surveillance of important pests and disease of coconut viz., rhinoceros beetle, red palm weevil, black headed caterpillar, mealy bugs, scales, rodents, shot hole borer beetle, Thanjavur wilt, stem bleeding, but rot, root (wilt), grey leaf spot, Thatipaka and pencil point diseases have been described.

326. JOSEPH, THOMAS. 1978. On bud rot disease of coconut. *Indian Cocon. J.* 9(4): 5-7. (CPCRI (RS), Kayangulam, Kerala)

Details on favourable environment for disease, pathogen, symptoms and control measures are discussed.

327. JOSEPH, THOMAS. 1980. Preliminary studies on fumigation of seed coconut. *In: Symposium on Plantation Crops, 2nd, Ootacamund, Jun. 26-29, 1979.* Proceedings of PLACROSYM II. Edited by C.S. Venkataram and others. p.380-385. (CPCRI(RS), Kayangulam 690533, Kerala).

In the face of increased need for exchange of coconut germplasm in the absence of any information on its fumigation prior to introduction, a preliminary trial was carried out to fumigate seed coconuts with methyl bromide to see if the treatment brings about any adverse effect on their germination. Two lbs methyl bromide per 1000 cu. ft. was applied for 2 h in two separate treatments. Equal number of nuts was fumigated twice with a lapse of 2 h and 7 days in between, respectively. Husked, dehusked as well as untreated control nuts showed no significant difference in the rate of germination as a result of fumigation.

328. KUMAR, P.S. and HEGDE, R.K. 1987. Studies on Phytophthora diseases of plantation crops. *Pl. Pathol. Newsletter* 5(1-2): 28. (Dept. of Plant Pathology, UAS, Dharwad 580005, Karnataka).

Five isolates from multistoreyed coconut and arecanut plantations in Kerala and Karnataka were identified as *P. palmivora* from coconut, *P. palmivora* MF<sub>4</sub> from *Piper nigrum*, *P. nicotianae* var. *nicotianae* from cardamom (*Eletaria cardamomum*) and *P. meadii* from arecanut. Isolates from cocoa, cardamom and black pepper belonged to the A<sup>1</sup> mating type, that from coconut was A<sup>2</sup> while that from arecanut was dual mating type (A<sup>1</sup> + A<sup>2</sup>). The suitability of various sterols for oospore production was determined, together with the effects of snail gut enzymes and horse dung infusion on inducing oospore germination.

329. LILY, V.G. 1984. Record of *Phomopsis cocoina* (Cooke) Panith. in stem bleeding affected coconut palm. *Curr. Sci.* 53 (13): 705-706. (CPCRI(RS), Kayangulam, Kerala).

During isolation for fungi associated with the disease affected palms, it was noticed that stem tissues from the diseased palms yielded a fungus which produced pycnidia in abundance in the culture medium. The identification of the fungus as *Phomopsis cocoina* was established at the CMI.

330. LILY, V.G. 1984. *Schizophyllum commune* Fr., first record from India on stem bleeding affected coconut palm. *Curr. Sci.* 53(24): 12-19. (CPCRI (RS), Kayangulam, Kerala).

Investigations were made on the fungi associated with stem bleeding disease of coconut. In addition to *Phomopsis cocoina* (Cooke) Punith: a basidiomycetous fungus was found and identified as *Schizophyllum commune*. Fr. This fungus is well known to cause many virulent wood rotting diseases in forest trees.

331. LILY, V.G. and PATIL, K.D. 1986. Stem bleeding disease of coconut in Kerala. *Indian Cocon. J.* 16(6): 11-12. (CPCRI (RS), Kayangulam, Kerala).

A brief account on coconut stem bleeding disease in Kerala with reference to its symptomatology, identification and possible fungal association is presented.

332. LILY, V.G. and RAMADASAN, A. 1979. Changes in phenolic content of coconut leaf in relation to the development of leaf rot. *Indian Phytopathol.* 32(1): 112-113. (CPCRI (RS), Kayangulam, Kerala).

The involvement of phenolic content in disease resistance has been recognized. A fungal disease, identified as leaf rot, frequently attacking the tender leaves, was investigated by analysing the different levels of phenolic compounds in diseased leaves. Results indicated significant increase in the total phenol content in leaf rot affected foliage.

333. LINGARAJU, S.; NAIK, S.T. and SASTRY, M.N.L. 1987. Host parasite relationship of *Pestalotia palmarum* Cooke. *Pl. Pathol. Newsletter* 5: 1-2 (Dept. Plant Path., UAS, Dharwad 580005, Karnataka).

Germ tube of conidia of *P. (pestalotiopsis) palmarum* penetrated coconut leaves directly. Higher germination rates (93%) were obtained on the upper surface than the lower (90%).

334. MATHAI, G. 1979. Diseases of oil palm and their relation to those of coconut. *Indian Cocon. J.* 10(2): 1-3 (RARS, Kumarakom, Kerala).

Coconut and oil palm are commonly liable to attack by many fungi. The *Phytophthora* sp. a universal rotting fungi which infects three species of palms (palmyra, coconut, and arecanut) has not reported to cause disease in oil palm yet. Incidence of *Ganoderma* sp. has not reached Kerala. Simultaneous growing of coconut and oil palm in Kerala may create further disease problems.

335. MATHEW, A.S. and RAMANATHAN, P.L. 1980. Incidence of stem bleeding disease of

coconut palm in relation to pH and electrical conductivity of soils. *J. Plantn Crops* 8(1): 40-42. (CPCRI (RS), Kayangulam, Kerala).

Soil reaction (pH) and electrical conductivity were determined in soil samples collected from sixteen stem bleeding prevalent areas comprising Kerala, Tamil Nadu, Karnataka, and Goa. These factors have no direct relation to the incidence of stem bleeding disease of coconut palm.

336. MATHEW, JACOB; NAMBIAR, K.K.N.; JOSE, C.T. and ANIL KUMAR. 1989. Stem bleeding disease of coconut; a method for indexing the disease severity. *J. Plantn Crops* 17(2): 80-84. (CPCRI, Kasaragod, Kerala).

A method for indexing the disease severity in stem bleeding affected coconut palms, based on lesion size and the score for tapering has been developed. The index can be worked out using the formula  $I = 1.80 + 4.3 t$ , where  $I$  is the lesion size expressed in 1000 cm<sup>2</sup> and  $t$  is the score for tapering. This will be useful in comparing the disease severity in different locations/cultivars as well as for a meaningful comparison of the efficacy of treatments.

337. MISHRA, D.; RATHI G.C. and SINGH, N. 1987. Fungi associated with coconut palm in Orissa. *Orissa. J. Hort.* 15 (Spl. iss.): 5-8. (OUAT, Bhubaneswar 751003, Orissa).

Diseased samples of coconut collected and studied from ten locations of Orissa revealed the presence of 17 fungi of which seven were pathogenic, six mildly pathogenic and four nonpathogenic.

338. MISHRA, D. and SINGH, N. 1987. Two new leaf diseases of coconut seedlings caused by *Curvularia* sp. *Indian J. Pl. Pathol.* 5(2): 208-209 (Dept. of Plant Pathology, College of Agric., OUAT, Bhubaneswar 751003, Orissa).

From the samples brought from the Govt.

seed farm of Orissa causal organisms were isolated, purified and maintained in potato dextrose agar medium. Morphological characters were studied, the identified organisms were used in pathogenicity tests. The inoculated plants developed typical symptoms. These fungi were found to be responsible for leaf spot and blight disease of coconut seedlings.

339. NAIR, M.K. 1989. Current knowledge, management techniques, areas of future work for major coconut disease in India. In: Coconut production and productivity, proceedings of the COCOTECH meeting, 26th, Bangkok, Thailand, May 15-19, 1989. Bangkok:APCC. p.198-200. (CPCRI, Kasaragod, Kerala).

A comprehensive idea on the present status in our knowledge on coconut diseases like Root (wilt), Thanjavur wilt and Crown choke is given. The future programmes of work on these major diseases are also outlined.

340. NAIR, M.K. 1989. A frame work for pooling of current knowledge and resources for a disease-free coconut industry. In: Coconut Production and Productivity; proceedings of the COCOTECH meeting, 26th, Bangkok, Thailand, May 15-19, 1989. p.270-271. (CPCRI, Kasaragod, Kerala).

A brief review of the coconut germplasm available with APCC member countries is presented. The future lines of research for a disease-free coconut industry has been proposed.

341. NAMBIAR, K.K.N.; ANIL KUMAR; SASTRY, KALPANA and JOSHI, Y. 1989. Seasonal effect on infection by stem bleeding pathogen *Thielaviopsis paradoxa*. *Curr. Sci.* 58: 34-35 (CPCRI, Kasaragod, Kerala).

Inoculation trials under field condition using stem bleeding pathogen *T. paradoxa* showed that the infection was quicker and tissue decay more in palms inoculated during

July to November. Young palms are more susceptible than older ones.

342. NAMBIAR, K.K.N.; JOSHI, Y.; VENUGOPAL, M.N. and CHANDRAMOHAN, R. 1986. Stem bleeding disease of coconut; reproduction of symptoms by inoculation with *Thielaviopsis paradoxa*. *J. Plantn Crops* 14(2): 130-133 (CPCRI, Kasaragod, Kerala).

Samples of diseased tissues were collected from coconut palms affected by the stem bleeding disease, growing in a number of locations in Karnataka, Kerala and Goa. The fungus *Thielaviopsis paradoxa* was consistently isolated from all locations. Characteristic symptoms of stem bleeding, in the form of rusty brown discolouration of bark, were reproduced in all the eleven inoculated palms located in Kasaragod, Appangala and Vittal. Inoculum comprised small pieces of coconut rachilla, used as a substrate, which were completely covered by an actively sporulating mycelium of *T. paradoxa*. These bits were introduced in bore-holes made on palm trunks. Symptoms appeared at inoculated sites within two wk. (at Appangala) to eight wk. (Kasaragod and Vittal). The organism was re-isolated from the tissue gathered from the inoculated palms.

343. NAMBIAR, K.K.N. and ROHINI, IYER. 1988. Important diseases of coconut in India. *Cord.* 4(2): 64-75. (CPCRI, Kasaragod, Kerala).

The article deals with coconut maladies like root (wilt), bud rot, stem bleeding, Thanjavur wilt/ganoderma, thatipaka and crown choke diseases. The etiology, symptomatology, epidemiology and control measures for the above diseases are briefly death with.

344. NAMBIAR, K.K.N., and SASTRY, KALPANA. 1988. Stem bleeding disease of coconut-current status and approaches for its control. *Philipp. J. Cocon. Studies.* 13(1): 30-32. (CPCRI, Kasaragod, Kerala).

The etiology, types and control of the stem bleeding disease were reviewed. The malady was traced as caused by either *Thielaviopsis paradoxa*, *Ganoderma lucidum*, stem borer; physiological disorders or lightning attack.

345. NATARAJAN, S.; BHASKARAN, R. and SHANMUGAM, N. 1986. Preliminary studies to develop techniques for early detection of Thanjavur wilt in coconut. *Indian Cocon. J.* 17(3): 3-6. (RARS, TNAU, Coimbatore, TNAU, T.N.).

Certain colorimetric and staining techniques for early detection of Thanjavur wilt have been given.

346. NEELAKANTAN POTTY, N. and RADHAKRISHNAN, T.C. 1978. Stem bleeding disease of coconut-nutritional relations. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I.* Edited by E.V. Nelliath and others. 347-350. (CCRS, Nileshevar, Kerala).

Stem bleeding incidence in coconut appears to be associated with deficient supply of N or an increase in P content without a concomitant increase in other nutrients. The imbalances in nutrition leading to disturbed physiological condition of the palms are discussed.

347. NISHITHA NAIK, V. 1990. Variability and characteristics of different isolates of *Thielaviopsis paradoxa*, pathogen of coconut stem bleeding disease. M.Phil. dissertation. Mangalore University, Mangalore. 74 p. (CPCRI, Kasaragod, Kerala).

Studies on the effect of natural and synthetic media on isolates of *T. paradoxa* revealed that natural media like sugar cane juice, apple juice, potato dextrose and coconut tissue extract agars and synthetic medium like dextrose asparagine phosphate agar supported

good growth and sporulation. Optimum temperature was 30°C and pH 5.5. Sucrose and asparagine favoured good growth while vitamins did not have any pronounced effect. Systemic fungicides like Bavistin and Calixin inhibited the growth of the pathogen *in vitro*.

348. PEETHAMBARAN, C.K. 1989. Diseases of arecanut and coconut palms. *In: Perspectives in phytopathology*. Edited by V.P. Agnihotri and others. New Delhi: Today and Tomorrow's Printers & Publishers. p.227-239. (Department of Plant Pathology, College of Agric., KAU, Trivandrum 695522, Kerala).

Diseases of *Areca catechu* caused by *Phytophthora arecae*, *Ganoderma lucidum*, *Colletotrichum gloeosporioides* (*Gongromerella cingulata*) and yellow leaf disease (no known causal agent) and coconut diseases-root (wilt) disease, leaf rot, bud rot and grey leaf spot or blight are reviewed.

349. PILLAI, N.G. and RAJU, C.A. 1985. A simple pressure injection device for application of antibiotics in coconut palms. *J. Plantn Crops* 13(2): 151-154. (CPCRI (RS), Kayangulam, Kerala).

The article describes a simple pressure injection device for application of antibiotics in coconut palms. The injector consists of a plastic cylinder of one litre capacity with a screw cap at the top and an outlet at the bottom. The reservoir has a valve to facilitate application of pressure (3.5 to 4 kg/cm<sup>2</sup>), through a foot pump. This method was found to be very efficient in applying other chemicals also.

350. PRASAD, S.S.; AMBASTA, K.K. and SINHA, A.E. 1985. Amylolytic activity of *Alternaria alternata* causing leaf spot of coconut. *Indian J. Mycol. Pl. Path.* 15(2): 224. (Dept. of Botany, Bihar Univ., Muzzafarpur, Bihar).

Proposed study on the amylase activity of the pathogen *Alternaria alternata in vitro* as

well as *in vivo*. The amylolytic activity of the pathogen *in vitro* varied with the incubation period. Maximum activity was observed on 2nd day after which it gradually declined. *In vivo* amylolytic activity was noticeably higher in diseased tissue than that of healthy leaf tissue.

351. PRASANNA, K.P.R. 1989. Incidence of coconut leaf drying in Karnataka State. *Indian Cocon. J.* 20(3): 18-20. (Coconut Development Board, Regional Office, Bangalore 560086, Karnataka).

Severe coconut leaf drying symptoms were observed in a few locations during winter months of 1988-89 in Karnataka State. Leaf drying was confined to lower older leaves only and upper younger leaves were healthy. The incidence and severity of leaf drying was generally maximum in rainfed gardens of 5-25 yr. of age whereas in aged gardens, namely those over 40-45 yr. were relatively free from symptoms. In some irrigated gardens also leaf drying was noticed. Prolonged dry spell coupled with low temperature and low relative humidity was attributed as the probable cause.

352. RADHA, K. 1984. Major coconut diseases and their control. *Indian Cocon. J.* 15(3-4): 33-36. (CPCRI, (RC), Kannara, Trichur, Kerala).

The coconut palm is as much prone to diseases as any other crop. Fatal diseases like Thanjavur wilt, anabe roga, ganoderma root rot and debilitating diseases like Root (wilt), leaf rot and stem bleeding occur in various parts of the country. Bud rot diseases is a killing malady prevalent in all coconut growing areas. In view of the resultant economic loss, these diseases are of major concern to all coconut growers. An understanding of the problems and ways of managing/controlling them is considered of common interest.

353. RADHA, K. and JOSEPH, THOMAS. 1982. Bud rot of coconut. *In: Workshop on Phytophthora Diseases of Tropical Cultivated*

Plants, CPCRI, Kasaragod, Sep. 19-23, 1980. Proceedings of Workshop. Kasaragod: CPCRI. p.11-16. (CPCRI(RS), Kayangulam, Kerala).

The present status of knowledge on bud rot disease and the pathogen indicates two important gaps, namely on the mode of dispersal of the pathogen and sufficient information on microclimate to develop a disease forecasting system as in the case of *Phytophthora*.

The requirement of frequent "favourable days" for the build up of the inoculum and the repeated infection cycles to reach the bud could be taken advantage of for prophylaxis. Application of antibiotics or chemicals having bactericidal properties along with fungicides to avoid secondary infection is to be considered.

354. RADHA, K. and JOSEPH, THOMAS. 1983. Bud rot disease of coconut. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.333-340. (CPCRI (RS), Kayangulam, Kerala).

Bud rot disease of coconut caused by *Phytophthora palmivora* (But.) often tends to be fatal. None of the environmental factors associated with the disease was found to be solely responsible for its development. Manifestation of the disease requires a combination of favorable factors, of which high relative humidity and low temperature are the most important factors. Number of "favourable days" determined the incidence and severity of the disease which in turn was dependent on the monsoon rains. Palms 3-20 yr exposed to suitable microclimate were the most susceptible.

The role of *Phytophthora palmivora* in the incidence of the disease, the nature of damage, and the possible implication of secondary invaders, such as bacteria in aggravat-

ing symptoms have been assessed. Production of oospores in infected tissues suggests the mode of survival of the pathogen in the cabbage of affected palms. Under favourable conditions the infection cycle could be completed in about a week.

355. RADHAKRISHAN, T.C. 1986. Control of bud rot caused by *Phytophthora palmivora* (But.) of coconut using newer fungicides. *Pesticides* 20(1): 45. (RARS, KAU, Pilicode, Kerala).

Ridomil MZ 72-Cumen L. mixture (101362-28-1) (0.5+0.08%) Bordeaux mixture (Boll-63-0) controlled bud rot effectively caused by *P. palmivora*. Fycap 40 A (1332-40-7) and Fytolan (1332-40-7) were less effective than the other two fungicides.

356. RADHAKRISHNAN, T.C. 1987. Symptom expression in stem bleeding disease of coconut in relation to season. *Indian Phytopathol.* 40(1): 100-102. (Citrus Project, S.V. Agric. College, Tirupathi 517 502, A.P.).

Observations on month-wise reaction of the diseased palms were recorded at two locations viz; RARS Pilicode and Nileshtar from July 1977 to December 1979. Based on the number and length of bleeding patches, the observations were graded as 'low', 'medium' and 'high'. At Pilicode 1.3% palms showed 'high' symptoms in September and 3% showed 'low' symptoms in November at Nileshtar 1.6% palms showed 'high' symptoms in August and 3.6% palms showed 'low' symptoms during June.

357. RADHAKRISHNAN, T.C. 1990. Control of stem bleeding disease of coconut. *Indian Cocon. J.* 20(9): 13-14. (RARS, KAU, Pilicode, Kerala).

Calixin @ 25g per 25 l of water applied once in four months was effective in controlling the disease.

358. RADHAKRISHNAN, T.C. and

**BALAKRISHNAN, P.C.** 1988. Evaluation of intensity of stem bleeding disease of coconut among the different cultivars. *Indian Cocon. J.* 19(7): (RARS, KAU, Pilicode, Kerala).

Out of 37 accessions, eight accessions were found to be disease free while the neighbouring palms were all affected. The accessions are Siam, Philippines, Jamaica, MYD, MGD, MOD, Mulithalai, Ceylon and Laccadive Ordinary.

**359. RADHAKRISHNAN, T.C. and NEELAKANTAN POTTY, N.** 1986. Varietal reaction to coconut stem bleeding disease. *Agric. Res. J. Kerala.* 18(1): 118–119. (RARS, KAU, Pilicode, Kerala).

Some data on varietal reaction to the disease, net yield and oil recovery are presented. The data show that the varieties vary widely in susceptibility to the disease. Among the seven indigenous varieties used in this experiment, Mysore and Godavari were the most resistant and West Coast Tall was the least resistant.

**360. RADHAKRISHNAN, T.C. and RAO, G.S.L.H.V., PRASADA.** 1988. Impact of drought on stem bleeding disease incidence of coconut. *In: National Seminar on Agrometeorology of Plantation Crops, KAU, Pilicode, Mar. 12–13, 1987. Proceedings of seminar.* p.90–92. (RARS, KAU, Pilicode, Kerala).

The disease incidence was more in 1978 (185 palms), 1979 (189 palms) and 1983 (188 palms) when the aridity indices were greater than 95% while it was less in 1980 (87 palms) when the aridity index was 47.75%. A significant positive correlation between the mean aridity index during the summer and disease incidence was noticed. A multiple linear regression was worked out for estimating the disease incidence based on monthly aridity indices during the summer (January to May).

**361. RAJAN, K.M.** 1987. The role of *Ganoderma lucidum* in coconut pathology. *In: International Symposium on Ganoderma Wilt Disease on Palms and other Perennial Crops, Soil and Water Management Research Institute, Thanjavur, Jan. 6–8, 1987. Abstracts of papers.* p.6–7. (RARS, KAU, Pilicode, Kerala).

Early detection of the disease is by looking for bleeding specks at the base of the trunk few centimetres above soil level. At this stage etiology may be confirmed by isolating the mycelium from sap wood in culture media. Organic soil amendments viz., non edible cakes and other industrial and agricultural waste materials may be applied and biological analysis of the pathogen and various saprophytes may be done at periodical intervals. This has to be coupled with the root or soil application of a suitable systemic and non-systemic fungicide in combination or in sequence for prevention of build-up of sufficient inoculum potential of the pathogen in and around susceptible plant tissue. A suitable schedule of chemical application has to be designed taking into consideration the particular ecological situation.

**362. RAJU, C.A.** 1984. Effect of methyl bromide fumigation on the fungi associated with seed coconuts. *Philipp. J. Cocon. Studies.* 9(1/2): 23–25. (CPCRI (RS), Kayangulam, Kerala).

Four fungi *Botryodiplodia theobromae*, *Pestalotia palmarum*, *Phoma* sp. and *Thielaviopsis basicola* associated with seed coconuts were exposed to methyl bromide (MeBr) fumigation directly as well as after implanting them into seeds at different concentrations and exposure timings, critical to seed coconuts. The fumigation was carried out in air tight chambers at the Plant Quarantine and Fumigation Station, Cochin and the fumigated cultures were transferred to fresh medium to study their viability. Observations on presence/absence of fresh growth on sub-culturing indicated that fu-

migation with MeBr at concentrations and exposure timings, critical for seed coconuts, is not sufficient to kill any of the four fungi.

363. RAMADOSS, N and BHASKARAN, R. 1987. Effect of fungicides in the management of Thanjavur wilt. *In: International Symposium on Ganoderma Wilt Disease on Palms and Other Perennial Crops, Soil and Water Management Research Institute, Thanjavur, Jan. 6-8, 1987. Abstracts of papers. p.12-13. (RARS, TNAU, Veppankulam, T.N.).*

Efficiency of Aureofungin-sol, Bordeaux mixture and neem cake in the control of Thanjavur wilt has been reported.

364. RAMADOSS, N.; GUNASEKARAN, M. and RAMANATHAN, T. 1985. Effect of neem cake on Thanjavur wilt of coconut. *Tamil Nadu Agric. Univ. Newsletter* 14(12): 1. (RARS, TNAU, Veppankulam, T.N.).

Field trials were conducted during 1981-84 to find out an effective control measure for Thanjavur wilt of coconut. Neem cake application at the rate of 10 kg/palm/year was found equally effective as combined treatment of stem injection of Aureofungin-sol. 2 g and copper sulphate 1g in 100 ml of water + soil drenching of 40 litres of Bordeaux mixture 1% + neem cake application (5 kg) for controlling Thanjavur wilt of coconut.

365. RAMADOSS, N.; GUNASEKARAN, M. and RAMANATHAN, T. 1986. Chemical control of Thanjavur wilt of coconut. *In: Seminar on Management of Soil Borne Diseases of Crop Plants (SOMSDOC) Jan. 8-10, 1986. Abstracts of papers. p.21. (RARS, TNAU, Veppankulam, T.N.).*

In the field experiment, efficiency of root feeding of fungicides was compared with soil drenching and trunk injection methods in the management of Thanjavur wilt of coconut suspected to be caused by *Ganoderma lucidum*

(Leys) Karst. Application of Carbendazim or Carboxin through roots at the rate of 2 g in 100 ml of water thrice a year was found to be equally effective in containing the disease. Further the damage caused by auger holes for stem injection could be avoided by resorting to root-feeding of the fungicides.

366. RAMADOSS, N.; GUNASEKARAN, M.; VIJAYARAGHAVAN, H. and RAMANATHAN, T. 1986. Studies on the destructive sampling of Thanjavur wilt affected coconut. *In: Seminar on Management of Soil Borne Diseases of Crop Plants (SOMSDOC), Jan. 8-10, 1986. Abstracts of papers. p.12. (RARS, TNAU, Veppankulam, T.N.).*

An attempt was made to study the internal pattern of tissue damage in Thanjavur wilt affected palms, the etiology of which is uncertain. Investigations revealed that the degree of infestation in the trunk region was more and a decreasing trend was noticed towards the crown region. The vascular region was completely disintegrated in an adult palm while in the young palm, necrotic areas were observed upto two-thirds of the total height. Isolation from infected roots and stem tissues yielded the fungi viz. *Botryodiplodia theobromae* Pat., *Ganoderma lucidum* (Leys) Karst., *Fusarium solani* and some sterile mycelia. The carbohydrate content was found to be lower in the diseased roots compared to healthy. The lower content of carbohydrates in diseased roots suggest that the infection may primarily be incited by a root invading pathogen.

367. RAMANATHAN, P.L. and ANTONY, K.J. 1976. Stem bleeding disease of coconut. *Coconut Bull.* 7(6 & 7): 11-12. (CPCRI, Kasaragod, Kerala).

Stem bleeding is a symptom of an abnormal condition due to many factors than as a disease like "bud rot".

368. RAMANUJAM, M.P. 1983. Toxin pro-

duction by *Pestalotia palmarum*. *Curr. Sci.* 52(24): 1195–1196. (Awwaiyr Govt. College for Women, Karikal, Pondichery).

A phytotoxin with a low mol. wt. and phenolic in nature, with a simple structure was isolated from cultures of *P. palmarum*, pathogen of leaf blight of coconut.

369. RAMAPANDU, S. and RAJAMANNAR, M. 1983. Symptomatology and indexing of Tatipaka disease of coconut. *Indian Phytopath* 36(4): 608–612. (AICCAIP Sub Centre, Razole, A.P.).

Observations on major symptoms of the disease are presented. Based on the frequency of occurrence and intensity of the symptoms, relative importance of different symptoms was fixed and due weightage and grade points were assigned to each symptom. By adding the weighted grade points of the different symptoms on a palm, the disease index is obtained.

370. RAMAPANDU, S. and RAJAMANNAR, M. 1987. Further investigations on the etiology and control of Tatipaka disease of coconut. *Andhra agric. J.* 34(2): 155–159. (AICCAIP Sub Centre, Razole, A.P.).

A review of investigations on the mysterious disease prevalent in Andhra Pradesh is presented. Sap transmission studies failed. Inoculation of 76 herbaceous plants to find an indicator plant was not successful. Electron microscopy revealed mycoplasma like bodies and virus-like particles. Chemicals like Vitavax, Kasumin, Benlate, Tetracycline H61, Aureofunginsol, certain antiviral compounds, Agrimycin and MBC, and hormones auxin H 61, GA, NAA, IAA and IBA failed to improve condition of diseased palms. Foliar and soil application of zinc and nitrogen appeared to be helpful in stopping the deterioration of diseased palms though there was no apparent remission of symptoms.

371. RAMAPANDU, S.; SATYANARAYANA, Y.; RAJAMANNAR, M. and CHIRANJEEVI, V. 1981. Seasonal variation in the manifestation of Ganoderma wilt disease on coconut. *Indian Cocon. J.* 12(3): 5–6 (AICCAIP Sub Centre, Razole, A.P.).

Linear spread of the disease is very much influenced by the range of difference in minimum and maximum relative humidity and rainfall. Higher the range of difference in relative humidity and lesser the rainfall, more will be the spread of disease. Linear spread was more during December to May and less during June to November.

Linear spread of the disease is favoured by low rainfall and low relative humidity during day-time while temperature does not appear to have much influence. The lesser linear spread of the disease during rainy season may be due to the adverse effect of high soil moisture on the causative fungus.

372. RAMASWAMI, R.; BHASKARAN, R. and JAGANATHAN, T. 1977. Epidemiology of Thanjavur wilt disease of coconut in Tamil Nadu. *Food Fmg Agric.* 9(6): 147–148. (Coconut Res. Station, Veppankulam 614 906, T.N.).

Effect of weather factors on Thanjavur wilt incidence has been discussed.

373. RAO, A.P.; LAXMINARAYAN, C. and PANDIT, S.V. 1977. The nature of coconut leaf-blight and its control. *Indian Phytopathol.* 28(4): 447–450. (Plant Pathology Laboratory, AICRP on Coconut & Arecanut, APAU, Razole 533 242, A.P.)

None of the five fungicides tested gave complete control of leaf blight caused by *Pestalotia palmarum* in coconut. Bordeaux mixture and Fytolan were relatively the most effective. The development of leaf blight infestation is described.

374. RAO, A.P.; SATYANARAYANA, B.; SUBRAMANYAM, K. and PANDIT, S.N. 1983. Control of Ganoderma wilt of coconut. In Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.347-351. (Dept. of Plant Pathology, Univ. of Hyderabad, Hyderabad, A.P.).

Sulphur arrested the spread of Ganoderma wilt of coconut temporarily. Later, the disease spread faster than in check plots due to annihilation of antagonistic soil microflora by sulphur. Vitavax (750 ppm) and aureofungin-sol + copper sulphate (100 ppm) checked the spread of the disease through soil and also its progress within an affected palm. Depending upon the age of the palm, type of soil, and the extent of initial bleeding zone, certain limitation on the efficacy of fungicides have been identified.

375. RAO, S.C. 1988. Leaf spot disease of coconut incited by *Bipolaris incurvata* (Bernad) Alcorn. *Curr. Sci.* 57(12): 674675 (CPCRI World Germplasm Centre, Port Blair, A & N Islands).

Leaf spot disease of coconut caused by *Bipolaris incurvata* has been found to occur in Andamans. The incidence was recorded as 0.12% in South Andaman, 1% in Little Andaman, and 1% in Campbell Bay. The severity of disease was higher during dry season.

376. RAO, S.C. 1988. Reaction of coconut cultivars of Andamans to grey leaf spot infection. *Indian Cocon. J.* 19(3): 7. (CPCRI, World Coconut Germplasm Centre, Port Blair, A & N Islands).

Reaction of different coconut cultivars to gray leaf spot (*Pestalotiopsis palmarum*) under field conditions in Andaman is reported. Katchal variety was found to be more tolerant (2% disease index) while all the 3 dwarf varieties known as King coconut in Andamans had maximum disease (19.6 to 23.3%).

377. RETHINAM, P. 1984. Thanjavur wilt disease of coconut in Tamil Nadu. *Indian Cocon. J.* 15(2): 5-11, 24. (CPCRI, Kasaragod, Kerala).

The cause of the Thanjavur wilt disease in Tamil Nadu is still not certain. Palms of age between 10-30 yr. are more susceptible and the disease is initiated by discolouration, rotting and decaying of the roots followed by discolouration, drooping of the leaves, unproductive inflorescences with arrested fruit setting and bleeding patches at the stem base gradually extending upwards. At the final stage the stem is rotten and the palm is dried and crown is ultimately blown off.

Mulching, regular irrigation and coconut husk burial decrease the disease intensity. Application of farm yard manure (200 kg), green leaves (50 kg) and neem cake (5 kg) per palm with soil drenching of 1% Bordeaux mixture thrice a year controls the disease of palms at the early stage of the disease, while at the same time increases yield. Stem injection of aureofungin-sol 2 g + CuSo<sub>4</sub> 100g in 100 ml. water thrice a year is also recommended as a controlling measure.

378. RETHINAM, P.; RAJAMANNAR, M. and NARASIMHACHARI, C.L. 1989. Tatipaka disease of coconut in Andhra Pradesh. *Indian Cocon. J.* 20(1): 1-4. (CPCRI, Kasaragod, Kerala).

Origin and spread, etiology, symptoms control and management, varietal screening and containing the disease by eradication were discussed.

379. RETHINAM, P.; ROY, A.K.; BARANWAL, V.K.; CHAKRABORTHY, B.K.C. and NAMBIAR, K.K.N. 1990. Crown choke disease of coconut. *Indian Cocon. J.* 20(9): 3-6. (ICAR, Krishi Bhavan, New Delhi 110 001).

During 1985-87 the spread of crown choke disease of coconut in Assam was investigated. The disease was prevalent in three

to six year old palms and symptoms of the disease are described. No fungal or bacterial pathogen was isolated, but a culture of saprophytic bacteria was observed in diseased plants. Boron levels were low in diseased plants and applications of boron controlled the symptoms. The results suggest that the malady is a micronutrient disorder and not a disease.

380. SANAL KUMAR, R. 1990. *In vitro* interaction of *Thielaviopsis paradoxa* with mycoflora of coconut root zone. M. Phil. dissertation. Mangalore University, Mangalore. 125 p. (CPCRI, Kasaragod, Kerala).

Fungi and bacteria were isolated from the root zones of stem bleeding affected coconut palms subjected to various treatments in a field trial for control of stem bleeding disease. Their population was maximum in summer (Feb.) and minimum in rainy seasons (June). NPK + dolomite + neem cake treatment showed higher bacterial and antagonistic fungal populations and less *T. paradoxa* population. *In vitro* interaction studies of *T. paradoxa* with thirteen fungal isolates revealed that *Trichoderma viride*-2 isolate exhibited maximum inhibition of *T. paradoxa* followed by *T. viride* - 1, *Rhizopus stolonifer* *Thielavia tervecicola* and *T. koningii*.

381. SATHIARAJAN, P.K.; RAJAN, K.M.; GOVINDAN, M.; RADHAKRISHNAN, T.C.; PHILIP, SUSAMMA; REHUMATUNIZA, T.J. and MATHEW, J. 1988. Disease and their management. In: Six decades of coconut research. Edited by M Aravindakshan and others. Trichur: Kerala Agricultural University. p.114-156. (RARS, KAU, Pilicode, Kerala).

A review of past work has been attempted. The main disease of coconut in Kerala, India, is root (wilt) disease which is caused by several pathogens. Other diseases affecting coconuts include stem bleeding, bud rot (*Phytophthora palmivora*), leaf rot (*Bipolaris halodes*) immature nut fall (*Phytophthora palmivora* var. *areca*) quick wilt, nutritional

disorders and disorders due to adverse conditions. Symptoms of the diseases and disorders are described and varietal susceptibility and control methods are discussed.

382. SATYANARAYANA, Y.; RAMAPANDU, S.; RAJAMANNAR, M. and CHIRANJEEVI, V. 1985. Control of *Ganoderma* wilt disease of coconut. *Indian Cocon. J.* 16(5): 3-5 (Agric. Res. Station, APAU, Razole, A.P.).

Chemical control of *Ganoderma lucidum* a fungus associated with the *Ganoderma* wilt disease in coconut has been discussed. All fungicidal treatments failed to offer complete control as evidenced by the mortality rate of the diseased palms. They only helped in delaying the death of palms for more than eight months.

383. SULLADMATH, V.V. and SANTAPPA, P.B. 1979. Nut fall in coconut associated with *Botryosphaeria rhodina* (Berks and Curt p. v. Arx.) *Curr. Res.* 8(1): 13. (Agric. Res. Station, UAS, Arsikere, Karnataka).

The fungus, found in plantations at Karnataka, enters nuts through injuries. Shedding occurs only when entry is near the stalk and of the buttons, immature nuts.

384. SULLADMATH, V.V.; SHANTHAPPA, P.B. and RAJANNA, H.P. 1980. Etiology of stem bleeding disease of coconut in semi dry tract of Karnataka. *Curr. Res.* 9(5): 73-75 (UAS, Bangalore, Karnataka).

Two distinct types of symptoms were observed in coconut palms affected by the stem bleeding disorder. In the first, bleeding was sparse and watery; crown leaves became desiccated and nuts were shed while the centre of the trunk rotted, resulting in tree death in about a year. In the second type, bleeding was red and turbid and the ooze usually hardened with no trunk rotting; trees recovered in six to eight months. Certain fungi and bacteria were isolated consistently from rotted

tissue beneath bleeding patches but not in the absence of rotting. Soil analysis indicated that pH, salt concentration and  $P_2O_5$  levels were unrelated to the incidence of stem bleeding and the disorder appears to be physiological.

385. SULLADMATH, V.V. and PONNAPA, K.M. 1979. Three new Deuteromycetes associated with leaf drying of coconut palms. *Curr. Sci.* 48(10): 450-451. (Agric. Res. Station, UAS, Arsikere, Karnataka).

Reports the severe leaf blight symptoms occurring in the Karnataka State in 1975-1977. The blight started at the base of the midrib of the leaflet of lower whorls and spread over to all the leaflets. Several Deuteromycetes hitherto not reported on coconut are described.

386. USMAN, N.M. 1988. Studies on stem bleeding disease of coconut, 1, Survival of *Thielaviopsis paradoxa* in soil, and 2. *in vitro* interaction of *T. paradoxa* with antagonistic fungi. M.Phil dissertation. Mangalore University, Mangalore 90 p. (CPCRI, Kasaragod, Kerala).

Studies on the survival of *Thielaviopsis paradoxa* in sandy, laterite and red loam soils showed that maximum percentage of chlamydospore germination was in red loam soil. Survival of the pathogen was higher in soils with cover crops and least in neem cake amended soil. *Trichoderma harzianum* isolate no.2 expressed maximum inhibition (97.4%) followed by *T. viride*-1 (94.7%) on *T. paradoxa*. These fungi caused lysis of *T. paradoxa* mycelium.

387. VIJAYARAGHAVAN, H. and RAMACHANDRAN T.K. 1988. Physiological studies on Thanjavur wilt affected coconut palms. *Indian J. Pl. Physiol.* 31(4): 437-439 (Cocon. Res. Station, RARS, TNAU, Veppankulam 614 906, T.N.).

Thanjavur wilt is a serious disease of

unknown etiology which affects coconut palms in the East Coast region of Tamil Nadu. The chlorophyll content, photosynthetic rate, soluble protein content and nitrate reductase activity were adversely affected in diseased palms while stomatal diffusive resistance and dark respiration were higher.

388. VIJAYARAGHAVAN, H.; RAMADOSS, N. and BHASKARAN, R. 1987. Approaches for early detection of Thanjavur wilt disease of coconut. In: International Symposium on Ganoderma Wilt Disease on Palms and Other Perennial Crops, *Soil and Water Management Research Institute, TNAU, Thanjavur, Jan. 6-8, 1987*. Abstracts of papers. p.16-17. (RARS, TNAU, Veppankulam 614 906, T.N.).

Certain physiological parameters viz., transpiration rate and stomatal diffusive resistance for early detection of Thanjavur wilt of coconut have been reported.

389. WILSON, K.I.; RAJAN, K.M.; NAIR, M.C. and BALAKRISHNAN, S. 1987. Ganoderma disease of coconut in Kerala. In: International symposium Ganoderma Wilt Disease on Palms and Other Perennial Crops, *Soil and Water Management Research Institute, TNAU, Thanjavur, Jan. 6-8, 1987*. Abstracts of papers. p.4-5. (RARS, Pilicode, Kerala).

In a number of palms in Trivandrum dt. the bark at the bleeding region gets easily peeled off from the underlying woody trunk. When the bark at the basal bleeding patches is removed, severe discolouration of tissues beneath can be noticed. Eventually a sort of dry rot sets in, resulting in the complete disintegration of the internal tissue which can be easily scooped out, thereby leaving a hollow region at the base of the affected palm. Such palms tend to topple down easily. This type of symptom is not reported for Thanjavur wilt. In a very few cases, fructifications of the fungus resembling *Ganoderma lucidum* could be noticed at the base of the diseased palms.

## 5. GENETICS CYTOGENETICS & PLANT BREEDING

390. BALAKRISHNAN, P.C.; DEVADAS, V.S. and UNNITHAN, V.K.G. 1988. Phenotypic stability of coconut (*Cocos nucifera* L.) cultivars for annual yield of nuts. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.5-6. (RARS, KAU, Pilicode, Kerala).

Phenotypic stability for annual yield of nuts of 32 coconut cultivars grown at RARS, Pilicode was estimated by non-parametric procedures using 20 years yield data from 1965 to 1984. Two non-parametric measures of phenotypic stability viz., mean of the absolute rank differences of the cultivar over the environments and variance among the ranks over the environments, were used for analysis. There was significant differences in the stability of the cultivars. West Coast Tall, Lakshadweep Ordinary, Java, Fiji, Philippines Ordinary, Andaman Ordinary and Godavari were found to be stable cultivars. Cochin China, S.S. Green, Lakshadweep Small etc. were highly unstable.

Since some cultivars showed a biennial (alternate) bearing tendency, the analysis was conducted using the cumulative yield of two consecutive years also. The cultivars recommended by the Kerala Agricultural University like West Coast Tall, Lakshadweep Ordinary, Andaman Ordinary, Philippines, and Java were stable for annual yield whereas Kappadam and Cochin China were stable for the cumulative yield of two consecutive years only.

391. BALAKRISHNAN, P.C. and KANNAN, K. 1988. Evaluation of certain coconut (*Cocos nucifera* L.) hybrids under rainfed conditions. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.10 (RARS, KAU, Pilicode, Kerala).

An experiment was conducted at RARS,

Pilicode to study the best hybrid in coconut under 15 hybrid combinations planted during 1973. Studies made upto 1988 on the performance of 15 hybrids show that the two hybrids West Coast Tall x Malayan Dwarf Yellow and West Coast Tall x Chowghat Dwarf Green are superior in respect of the production of nuts and copra and is followed by West Coast Tall x Chowghat Dwarf Orange and Fiji x Chowghat Dwarf Orange.

392. BALAKRISHNAN, P.C.; KANNAN, K. and NAIR, R.R. 1987. Effect of potential removal of husk from the stalk end of coconut seed nuts on germination and growth of seedlings. *Indian Cocon. J.* 17(10): 1-2. (RARS, KAU, Pilicode, Kerala).

Careful selection of seedlings in the coconut nursery on the basis of early germination, girth at collar and the number of leaves ensures their better performance in the main field. The experiment conducted at RARS, Pilicode during 1985-86 showed that nuts sown in poly bags after removing top one-third portion of the husk from the stalk end influenced significantly the germination and girth of the seedlings.

393. BALAKRISHNAN, P.C. and NAMBOODIRI, K.M.N. 1987. Genetic divergence in coconut. *Indian Cocon. J.* 18(7): 13-16. (RARS, KAU, Pilicode, Kerala).

Genetic divergence study was undertaken with 24 cultivars of coconut maintained in the germplasm collection of the RARS, Pilicode during 1981-82. It included 120 palms of the same age group representing 7 exotic and 17 indigeneous cultivars of the Tall group. The 24 cultivars fell into 6 distinct clusters based on the genetic distances among them. Cultivars of the same place of origin fell into different clusters, while those of diverse origin fell into

the same cluster.

The study revealed that there is wide genetic distance among the cultivars and it is at the maximum between the cultivars in cluster IV and VI.

394. BALAKRISHNAN, P.C.; SUKUMARAN NAIR, S. and KUMARAN, K. 1988. Crop Improvement. *In: Six decade of coconut research*. Edited by M. Aravindakshar and others. Trichur: Kerala Agricultural University. p.7-36. (RARS, KAU, Pilicode, Kerala.)

Work done on crop improvement in coconut viz., morphological studies, floral biology, pollination, nut characters, production of planting materials, Nursery techniques and Breeding aspects have been compiled.

395. BALAKRISHNAN, P.C. and VIJAYAKUMAR, N.K. 1988. Performance of indigeneous and exotic cultivars of coconut in the northern region of Kerala. *Indian Cocon. J.* 19(1): 1-4. (RARS, KAU, Pilicode, Kerala).

In a study conducted at RARS, Pilicode, 50 steady bearing cultivars of coconut were evaluated for mean yield and nut characteristics during 1984-85. The cultivars included both exotic and indigeneous types coming under Tall, Semi Tall and Dwarf groups. Based on average number of nut production for the past six years, Spicata comes in first rank. The study reveals that cultivars like Spicata, Philippines, New Guinea and Lakshadweep Ordinary cultivars in Kerala under rainfed conditons.

396. BAVAPPA, K.V.A. and RAO, E.V.V BHASKARA 1985. Coconut breeding; an overview. *In: SABRAO Congress, 5th Bangkok, Nov. 25-29, 1985*. Proceedings of congress. p.545-556. (CPCRI, Kasaragod, Kerala).

Research on coconut dates back to early part of the century in India. The initial programs included standardization of mother palm and seedling selection methods. The improvement

in the yield that could be achieved through these programs was only 8-15%. Germplasm collection and conservation programs were initiated in early 1930s which received further impetus with the support of IBPGR during 1970s. At present, sizeable collections are being maintained in India, Ivory Coast, Philippines, Indonesia, Malaysia and Sri Lanka. Indian germplasm holding with 118 accessions from 25 countries represent the largest collection in terms of accessions while the collection in Ivory Coast with about 70 trees in each accession from 32 different origins is the biggest population of coconut germplasm assemblage. Indigenous cultivars Andaman Ordinary and Lakshadweep Ordinary and exotic cultivars Philippines Ordinary and SS Green gave 25-35% more yield in India in terms of number of nuts compared to the local Tall cultivars. Higher Yields could be achieved with the advent of hybrid production. The Chowghat Dwarf Orange x West Coast Tall (CDO x WCT), Lakshadweep Ordinary x Chowghat Dwarf Orange (LO x CDO) and Lakshadweep Ordinary x Chowghat Dwarf (LO x GB) hybrids yielded 26-42% more than the Tall parents. The MAWA hybrid which yields about 6 ton of copra by 20th year has been found to perform well in Malaysia and Philippines also. Two hybrid combinations LO x CDO and LO x GB in India and MAWA hybrid of Ivory Coast were also found to perform well under drought conditions. CDO x WCT in addition to being less suscptible to root(wilt) disease, gave much higher yields even under diseased conditions. In Indonesia the Bali Tall x Nias Yellow Dwarf gave almost double the yield of Tall cultivars. In Philippines and Malaysia the different hybrid combinations with Malayan Dwarfs and Local Talls gave differential performance indicating the necessity for careful selection of parental lines in the hybridization programmes. Improvements in the hybridization techniques made commercial production of the coconut hybrids an easy proposition through establishment of seed gardens even at small

farmers' level. However, much work need to be done in developing hybrids tolerant to diseases and pests and to adverse environmental conditions such as drought and salinity. The current research achievements in developing the plantlets through leaf cultures in India has opened new possibilities for both mass multiplication of elite palms, superior parental materials for seed gardens and for in vitro screening against disease complexes.

397. BAVAPPA, K. V. A. and SUKUMARAN, C. K. 1983. Coconut improvement by selection and breeding; a review in the light of recent findings. *In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976*, edited by N.M. Nayar. New Delhi: Wiley Eastern. p. 44-55. (CPCRI, Kasaragod, Kerala).

The major breeding objectives have been identified as higher yield of oil per unit area of coconut plantation and resistance/tolerance to serious diseases such as root (wilt), 'Thattipakka', and stem bleeding.

The breeding systems vary widely in Tall and Dwarf cultivars. The advantages of selecting the best 10% of palms in a given population as mother trees for seed nut collection and breeding purposes have been indicated. Studies on the relationship between yield of nuts, copra content per nut, total yield of copra/palm and yield of oil/palm showed that in West Coast Tall, the mean copra content/nut, though negatively correlated with yield, does not affect annual outturn of copra/palm, the threshold value being 162.6 nuts, and that the yield of oil/palm yield of nuts were significantly and positively correlated. The necessity for applying selection pressure age in addition to number of nuts have been indicated keeping in view the variability and heritability data available for these characters. Selfing of West Coast Tall palms confirmed the earlier observation that it is heterozygous for height while Chowghat

Dwarf orange variety is heterozygous for colour, vigour, and stature. Palms which breed true for these characters are also present in the population. In addition to the wide variations observed in the percentage of heterozygotes for vigour realised by selfing or under open pollination of Dwarf Orange or under specific cross combinations with Tall, the progenies were also observed to segregate for colour.

Further experiments are to be taken up for a better understanding of the genetic make up of the Tall and Dwarf varieties. The different approaches that may be pursued for improving their genetic base and the possibilities of realising a higher percentage of hybrids in the Dwarf Tall process are discussed.

398. BHASKARAN, P. V.; BALACHANDRAN NAIR, G. K.; PADMANABHAN THAMPI, A.; SIVASHANKARA PILLAI, K.; RAMACHANDRAN NAIR, V.; MADHAVAN NAIR, G.; PUSHPANGADAN, K.; SUKUMARAN, K. M.; RAGHAVAN PILLAI, G. and KOSHY, E. P. 1988. Forecast of coconut yield using biometric characters of young palms. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkava, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.40.* (Coconut Res. Station, KAU, Balaramapuram, Trivandrum, Kerala).

Correlation and path-coefficient analysis of various growth characters of young coconut palms of the age group 4-7 years with long term yield of coconut revealed that number of leaves was the major contributor towards variations in the nut yield of coconut. Selection of palms for nut yield could be done effectively on the basis of number of functioning leaves as early as in the sixth year after planting. Prediction equations were evolved for making advance estimates of probable production from young palms based on the morphological traits, assuming a more or less constant environment to continue in the orchard. An attempt was

also made to find the desirable characteristics of pre-potent palms to be identified as parents for further breeding. It was found that selection of plants for leaf number and leaf production rate at early stages would be a quick method of genetic improvement. Replacement or rejuvenation of undesirable young palms with sufficiently lesser number of leaves should be an important aspect of effective farm management.

399. BHAT, S.S. 1990. Cytoembryological investigations in dwarf coconuts (*Cocos nucifera* L.) M. Phil. dissertation. Mangalore University, Mangalore. p.81. (CPCRI, Kasaragod, Kerala).

The investigations deal mainly with the breeding behaviour of Chowghat Orange Dwarf (COD), apomixis and an elaborate study on pollen viz., pollen characteristics, pollen tube growth, viability, factors affecting pollen germination and storage, *in vitro* germination of pollen, structure of embryo sac and path of pollen tube growth. The results obtained are summarised and illustrated with colour photographs.

400. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD. 1981. Interim report on coconut germplasm collection in Pacific Ocean Islands. *Co-community APCC/QS/39/82:1-3*.

A collection of coconut germplasm in seven Pacific Ocean territories was undertaken by the CPCRI to conserve coconut germplasm with a view to screening for their reaction to root(wilt) disease in Kerala.

Since a large variability is seen in coconut palms in the natural stands of these territories every attempt was made to sample this natural variability although it has not been 100% successful. These variables are Rennel Tall, Solomon Tall, Fiji Tall, Samoan Tall, Tahiti Tall, Rangirao Tall, Dwarf yellow, Dwarf Orange and Niuleka (Dwarf Fiji).

The collected nut samples were sent to the proposed World Coconut Germplasm Centre to be established there under the auspices of the CPCRI.

401. DAVIS, T.A. and GHOSH, S.S. 1983. Phylloidy of palm spadices and flowers. *Indian Cocon. J.* 13(5): 1-5 (Indian Statistical Institute; Calcutta 700 035, W.B.)

In exceptional palms, the entire spadix or individual spikes or the male and/or the female flowers transform to vegetative shoots popularly known as bulbils. Instances of such transformation were recorded in the following species: *Areca catechu*, *Arenga pinnata*, *Borassus flabellifer*, *Chrysalidocarpus lutescens*, *Chuniophoenix hainanensis*, *Cocos nucifera*, *Cocothrinax argertata*, *Elaeis quinensis* and Phoenix species. The peculiarities are briefly described. Clonal propagation in *Cocos nucifera* was made possible by successfully layering coconut bulbils. But such clonally propagated bilbil shoots produce only vegetative shoots in the place of normal inflorescences. In exceptional palms, the inflorescence typically in spadix, give rise to peculiar developments that superficially resemble the bulbils seen in some species of Agavaceae and Liliaceae. Coconut spadix is modified into a large bilbil shoot, or the various spikes transform into smaller bulbils, or in yet other cases, the female and/or male flowers transform into tiny vegetative shoots resembling bulbils. The female flowers of coconut turn into bilbil shoots in rare palms.

402. DAVIS, T.A. and MALIANGKAY, R.B. 1988. Coconut bisexual flowers and their significance for hybrid seed gardens. *Cord* 4(1): 22-34 (JBS Haldane Res. Centre, Nagercoil-4, T.N.)

Among the tall and dwarf varieties of coconut as well as the hybrids between them, occasionally one comes across hermaphrodite or bisexual flowers. Some individual palms produce a high percentage of hermaphrodite

flowers while a great majority of others do not produce any bisexual flower at all. There is clear evidence that coconut flowers at the primordial stage are bisexual with the potential to develop both stamens and pistils in the same flower. But at a later stage of development, one grows into a female flower whose male organs are reduced to a ring of six staminodes. Another develops into a staminate flower whose pistils are reduced to three pistillodes. However, due to genetic, ecological, physiological or other factors, some unisexual flowers show an atavistic display of hermaphroditism. Bisexual flowers are observed among tall and dwarf variety palms. The negligible percentage of bisexual flowers that occur in large estates where the fruits are not used as seeds has no major disadvantage. But seed gardens, especially where inter-varietal hybrid seeds are produced, hermaphrodite flowers are capable of reducing the percentage of true hybrids. Timely removal of hermaphrodite flowers, therefore, would reduce the occurrence of undesirable true to mother type progeny and enhance the success of inter-varietal hybridization.

403. DAVIS, T.A.; SUDASRI, H. and AZIZ, H. 1981. Significance of hermaphrodite flowers in coconut breeding. *Proc. Indian Nat. Sci. Acad. (B)* 47(4): 527-535. (JBS Haldane Res. Centre, Nagercoil - 4, T.N.).

Of 200 Nias Yellow Dwarf palms studied, 54 (27%) bore at least one hermaphrodite flower in three months. At the time of emasculation for dwarf x tall hybrid seed production most hermaphrodite flowers are mistaken for female flowers. This leads to production of undesirable dwarf seedlings similar to the seed parent.

404. GHOSE, M. 1979. Ontogenetic study of stomata and trichomes in some palms. *Phytomorphology* 29(1): 26-33. (Indian Statistical Institute Calcutta, 700 035, W.B.)

*Areca catechu*, *Borassus flabellifer*, *Cocos nucifera* and *Elaeis guineensis* are tetracytic. In *C. nucifera*, both the polar and the lateral subsidiary cells are cut off by the neighbouring protodermal cells. Each lateral subsidiary cell is the result of a longitudinal division of a trapezoid cell formed by two oblique divisions of a lateral protodermal cell. The ontogeny of stomata conforms to the perigenous type with non-intersecting oblique division. The structure of mature trichomes in the four species is different but the early development is almost similar. The first division of the trichome meristemoid is usually transverse, followed by a longitudinal and then a transverse division. The number of division varies from species to species.

405. GHOSE, M. 1984. Vessel elements in roots of young palms. *Principes* 28(4): 179-186. (Indian Statistical Institute, Calcutta 700 035, W.B.)

Perforation plate type, end wall slope, and length to width ratio in wide vessel elements from roots of seedlings of 17 species of palms are described. Vessel elements with two different (i.e., "mixed") perforation plate type or end wall slopes occur in many of the specimens. There is little resemblance between the sequence of the species according to Moore's (1973) systematic classification of palms, and the sequence according to the length to width ratio of vessel elements.

406. GHOSE, M. 1987. The anatomy of roots in young palms. *J. Indian Bot. Soc.* 66: 220-226. (Indian Statistical Institute, Calcutta 700 035, W.B.)

The anatomy of roots of 19 species of palm seedlings is described. Root hairs develop in young *Phoenix sylvestris* and *Roystonea regia*. Maturation of exodermal cells in the roots of young palm proceeds centripetally in contrast to the simultaneous centripetal and centrifugal maturation in roots of adult palms. The

The mature stomata on the leaves of

phellogen does not develop in the roots of young palm. Difference between young and adult palms have been discussed. The "polystelic conditon" or "lobed stele" is absent in the roots of young palms although it is well-known in some adult palms. Cortical fibres are absent and pericycle is one-layered in *Cocos nucifera* and a few other young palms.

407. GHOSE, M. and JOHRI, B.M. 1987. Cell inclusions in vegetative structure of young palms. *Proc. Indian natn. Sci. Acad. B* 53(2): 193-196. (Indian Statistical Institute, Calcutta 700 035, W.B.).

The occurrence and types of cell inclusions, or ergastic substances in 19 species of seedling palms are described. Two types of silica bodies occur in these palms - 'hat-shaped or conical' type and 'spherical or druse-like'. Starch grains have been observed in all the plant organs, the hilum of grains may be concentric or accentric. Large starch grains occur in *Caryota urens*, and smaller ones in *Roystonea regia*, *Cocos nucifera* and *Rhapis excelsa*. Calcium oxalate occurs as bundles of raphide needles in distinct raphide sacs, in the mesophyll of lamina, and cortex of root, stem and petiole. Tannins occur in almost all the palms in mesophyll cells, ground parenchyma of leaf axis, root and stem.

408. GHOSE, M. and JOHRI, B.M. 1990. Anatomy of the stems of seedling palms. *Proc. Indian Acad. Sci. (Plant Sci.)* 100(4): 215-223. (Indian Statistical Institute, Calcutta 700 035, W.B.)

The anatomy of stem in 19 species of seedling palms is described in representative species from all the sub families of Palmae, except Nypoideae and Phytelphantoideae. Morphologically, the stem of juvenile palm is abconical of the central cylinder with a wide cortex exceeding the diameter, while that of the adult palms is mostly solitary columnar. The cortex of stems in young palms is very

wide, and often exceeds the diameter of central cylinder in contrast to very narrow cortex in adult palms. The number of vascular bundles increase several times from the lower to the upper level of juvenile axis, whereas the number of bundles more or less remains the same at different levels of the stem in adult palms. There is a wide meristematic zone towards the tip of axis and just below the base of the young leaves which is responsible for widening of the seedling stem until it attains the mature stem diameter. The xylem of central vascular bundles in young palms is mostly composed of protoxylem elements, but in adult palms, they include well-developed metaxylem vessels. The central ground parenchyma is compact in young palms, spongy and lacunose in adult palms.

409. GHOSE, SUGATA AND DEBNATH, K. 1986. A nut morphological study of East Coast (Arsampathy) Tall coconut. *Indian Cocon. J.* 18(6): 12-14. (Coconut Development Board, State Centre, Guwahati, Assam).

Four morphological characters viz., circumference, length and width, husk thickness and nut weight of East Coast Tall (Arsampathy) coconut are studied. The circumference, length and width, thickness of husk and nut weight ranges from 52-60 cm and 44-52 cm, 1.8-2.9 cm and 650-920 gm respectively.

410. GHOSH, S.S. 1978. Asymmetry in aestivation of the female flowers in an unusually large spadix of coconut (*Cocos nucifera* L.). *Indian Cocon. J.* 8(10): 3-6. (Indian Statistical Institute, Calcutta 700 035, W.B.).

Observations were made on an unusually large coconut spadix bearing 331 female flowers. The presence of many female flowers in each spike, some of them bearing twin females enabled to have additional information on the morphology of the coconut flower.

The twin female flowers resemble the two males in each flower cluster of caryotoid

**palms** for their calyx arrangement. The flower on the left side has right imbrication of calyx which is mirror image of that on the right side. This pattern is irreversible and independent of the spirality of the spike. In about half the number of male flowers, the sepals do not show any clear imbricate arrangement since two margins do not overlap.

**411. GOPIMONY, R.** 1984. Preliminary observations on a local coconut type 'KOMADAN'. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V.* Edited by K.V.A. Bavappa and others. p.177-179. (Dept. Plant Breeding, College of Agric. KAU, Trivandrum 695 022, Kerala).

'Komadan' a local coconut off-type, popular in the Central Travancore area of Kerala, is compared with the West Coast Tall (WCT) cultivar with regard to population structure, morphological characters, and seedling progeny analysis. The population structure, morphological characters, and seedling progeny analysis. The population structure of the two types based on average nut yield per tree per year was found to be basically different. While 99 per cent of the 'Komadan' population was giving more than 80 nuts per tree per year, only 15 per cent gave that yield in WCT.

The mean values of morphological characters also showed the superiority of 'Komadan' for the nine quantitative characters studied. The 'Komadan' type further exhibited superior seedling vigour, in terms of germination per cent, height, collar, girth, mean number of total leaves and mean number of split leaves.

**412. IYER, R.D.; RAO, E.V.V. BHASKARA; SUKUMARAN, C.K. and JACOB, P.M.** 1981. Towards an ideal plant type concept in coconut. *In: Symposium on Plantation Crops, 4th, CFTRI, Mysore, Dec. 3-5, 1981. Proceedings*

of PLACROSYM IV. Edited by S. Vishveshwara and others. (CPCRI, Kasaragod, Kerala).

The average yield of coconut in India is 35 nuts/palm/year, whereas some of the elite palms are reported to have yields ranging from 200 nuts to over 600 nuts under apparently little or no management. A survey of these elite palms indicated that they are free from disease, although growing in diseased environment for two or more decades. All these elite palms conform to a spherical or hemispherical canopy, the other being the large number of leaves showing a slower rate of senescence, and well-supported (non-buckling) bunches which become ready for harvest at regular intervals. A large number of vegetative and floral characters have been recorded for the inclusion in a model for an ideal plant type in coconut.

The seedling progenies raised from the elite palms have been studied using a cumulative indexing procedure and compared with seedling progenies of certain pre-potent palms which show a high rate of yield transmitting ability. Some progenies appeared more uniform than others, thus bearing a close resemblance to those of the prepotent palm. They have been planted both in healthy and disease-affected areas for analysing their further behaviour. Details of above study are discussed in this paper.

**413. IYER, R.D.; SATYABALAN, K.; SUKUMARAN, C.K. and RAO, E.V.V. BHASKARA.** 1984. Breeding methodology as applicable to coconut improvement. *In: Advances in cytogenetics and crop improvement; proceedings of the international conference, Banaras Hindu University, Varanasi, Mar. 3-6, 1978. p.283-289. (CPCRI, Kasaragod, Kerala).*

An impact on coconut production and productivity in the coming decades can be realised both by bridging the extension gap

by adoption of better management, and the research gap by the use of superior planting material for underplanting as well as new plantings. Among the long term measures, rapid identification of prepotents among high yielders with disease resistance should be pursued vigorously. Simultaneous efforts to perfect the tissue culture and other vegetative propagation methods should be augmented in order to achieve a rapid production break through in the near future.

414. JACOB, P.M. and KRISHNAMOORTHY, B. 1981. Observations on the coconut gene pool in Lakshadweep Islands. *In: Symposium on Plantation Crops, 4th, CFTRI, Mysore, Dec. 3-5, 1981. Proceedings of PLACROSYM IV. Edited by S. Visveshwara and others. (CPCRI, Kasaragod, Kerala).*

The coconut palms in Lakshadweep Islands are high yielding, free from major diseases and are in highly over crowded standards. Laccadive Ordinary, Laccadive Micro, Kaithathalli and Dwarf palms bearing green and orange nuts are the types cultivated in these islands. Laccadive Micro is a high yielding cultivar with highest oil content in copra among all cultivars. However, the population of these cultivars has been on the decline due to introgression resulting in the intermediate types between Laccadive Ordinary and Laccadive Micro.

415. JOSE, A.I. 1988. National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. 56.p (KAU, Trichur, Kerala).

Abstracts of 63 papers presented at the symposium are included. Topics covered include (1) breeding for nut and copra yields and quality attributes, (2) breeding for pest, disease and stress resistance, (3) biotechnology, (4) crop management and (5) processing technology.

416. JOSE, JOSEPH. 1990. Studies on phyllotaxy, apical organisation and bulbil

formation in coconut. PhD. thesis Calicut University of Calicut, Calicut (Dept. of Life Science, Univ. of Calicut, Calicut, Kerala).

Earlier literature is reviewed on the anatomical and histological studies conducted regarding the origin and development of "bulbils". For easy recognition the term "bulbil" is continued to be used even though there exists two different types. The simple type where the entire spadix develop into a single seedling is to be called as bulbil while the compound one where individual flowers develop into separate seedling is an example of typical viviparous condition.

Studies were conducted on leaf arrangement based on the linear and angular measurements taken from the shoot apical region progressively down to the trunk. From mathematical calculations on the foliar helix of coconut, a single space curve (geneic spiral) is proposed, in contrast to the generally accepted multiple helices leaf arrangement, put forward by Plantefol. Hence a single space curve as proposed in the present contribution would explain leaf initiation and development in the coconut palm.

417. KALATHIYA, K.V. and SEN, N.L. 1990. Correlations among fruit characters in coconut (*Cocos nucifera* L.) cv. dwarf green. *In: Symposium on Plantation Crops, 9th, CCRI, Chickmagalur, Dec. 5-7, 1990. Abstracts of papers. p.54. (Plantation Crops Res. Station, GAN, Mahuva 364 290, Gujarat).*

Correlation coefficients were worked out between yield, oil percentage and other fruit characters in a set of 30 palms of coconut variety 'Dwarf Green'. The weight of copra was found to be significantly and positively correlated with size of the fruit, volume of the fruit, weight of husked nut, weight of shell and weight of kernel. The path coefficient indicated the high positive direct effect of weight of kernel on

weight of copra. Oil percentage was found to be significantly and positively correlated with number of fruits per palm and negatively correlated with weight of copra and weight of husk.

418. KANNAN, K. 1982. West Coast Tall, how to improve its production potential. *Indian Cocon. J.* 12(6-9): 5-8. (RARS, KAU, Pilicode, Kerala).

Investigations have been made on improvement of WCT coconuts which contributes 95% of the plantation in Kerala. Selection of mother palms, identification of prepotent palms and collection of seed nuts from such palms are of genetic importance and proper management practices also contribute to a greater extent in improving coconut variety.

419. KANNAN, K. and NARAYANAN NAMBIAR, P.K. 1979. Mother palm and seedling selection in coconut. *Agric. Res. J. Kerala* 17(1): 1-6 (Coconut Res. Station, KAU, Pilicode, Kerala).

Studies were undertaken at the Coconut Research Station, Pilicode to find out influence of mother palm and seedling selection on the performance of progenies. Palms yielding more than 80 nuts per annum and palms selected at random (bulk mother palms) are found to produce high yielding progenies. Palms giving an yield of less than 20 nuts are definitely unsuitable for seednut selection. Seedling selection though necessarily need not be as stringent as is advocated at present, since the yield difference between vigorous and intermediate seedlings is not significant. However, for ensuring better establishment, early flowering and higher yield, poor seedlings should be rejected.

420. KARTHA, S. 1981. Embryo of coconut and its germination (described and illustrated). *J. Plantn Crops* 9(2): 125-127. (Nehru Sci. Centre, Bombay 400 018, Maharashtra).

Attempts to study the morphology of embryo of coconut and the behaviour of its single cotyledon during germination are described.

421. KRISHNAMOORTHY, B. and JACOB, P.M. 1984. Fruit component analysis in Lakshadweep coconut. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.180-183. (ICAR Res. Complex for Lakshadweep, (CPCRI), Minicoy, Lakshadweep.)

The Niu kafa-Niu vai Integression (NKNVI) method was used for the comparison of the different types of coconut found in Lakshadweep Islands. The highest proportion of husk in the fruit and a high proportion of endosperm in the nut are characteristic of the Niu kafa class, while a low proportion of husk and high proportion of water in the nut are characteristic of the Niu vai class. Fruit component analysis indicated that the different types of Lakshadweep coconuts belong typically to the "Niu kafa" class and the Laccadive Small is of intermediate nature, and arose perhaps due to introgressive hybridization between the Laccadive Micro and the Laccadive Ordinary types.

422. KUMAR, A.A.S. and PILLAI, S.J. 1989. Nursery observations on the production of West Coast Tall and Komadan quality coconut seedlings. *Indian Cocon. J.* 20(2): 8-12 (College of Agric. KAU, Trivandrum 695 022, Kerala).

Seednuts of the 2 cultivars were sown in the nursery in June and germination was assessed at 3, 4, 5, 6 and 8 months after sowing. Upto 5 months, the rate of germination was higher in Komadan than in West Coast Tall (WCT) but WCT showed slightly higher germination percentage. WCT also produced a greater number of seedlings but seedling quality was higher in Komadan.

423. KUMAR, G.N.M. and ROKHADE, A.K. 1983. Polyembryony in coconut (*Cocos nucifera* Linn.). *Indian Cocon. J.* 14(4): 11. (College Agric, UAS, Dharwad, Karnataka).

Single nut of the variety Arsikere Tall gave rise to 3 seedlings.

424. LOUIS, I. HENRY. 1977. Bisexual flower of coconut palm. *Kalaikadir Jan.*, p.21-22. (School of Genetics, TNAU, Coimbatore, T.N.)

Bisexual flower in coconut palm though seen sporadically has many significances. It reminds us of the evolutionary trend of the flowers in coconut palm. The article carries a beautiful plate of a bisexual flower.

425. LOUIS, I. HENRY. 1981. Genetic variability in coconut palm. *Madras Agric. J.* 68(9): 588-593. (School of Genetics, TNAU, Coimbatore, T.N.)

Phenotypic and genotypic variability in coconut palm was studied in a collection of 25 varieties and two hybrids. A wide range of phenotypic variation was observed in these varieties. Among the characters, number of leaves per year, number of leaves on the crown, number of spathes per year, number of female flower per palm, setting percentage and number of nuts were found to have high genetic advances and these characters may be considered reliable for selection.

426. LOUIS, I. HENRY. 1983. Genetic studies in coconut, (*Cocs nucifera*. L.). PhD. Thesis, IARI, New Delhi. (School of Genetics, TNAU, Coimbatore, T.N.)

Thirtyone accessions of a germplasm collection of exotic and indigenous origins exhibited wide genetic divergence. The genetic divergence in this monotypic species is mostly shaped by the nut characters such as thickness of the shell thickness of the kernel, thickness of the husk and weight of the kernel.

Growth characters that contributed to divergence were the girth of the collar in three year old seedling, length of the leaf and pre-flowering period.

Geographical origin of an accession need not necessary relate to genetic divergence since accessions from geographically distinct countries were found in the same cluster.

Phenotypic variance was greater than genotypic variance for all the characters. Estimated heritability was the maximum for the thickness of the shell followed by preflowering period, thickness of the kernel, thickness of husk, weight of the kernel and copra per nut.

The number of female flowers had the maximum genetic advance, followed by weight of kernel per nut, weight of copra per nut, number of nut per year, and pre-flowering period. Selection for these characters would achieve yield improvement.

The correlation values were positive in eleven and negative in seven characters. The length of the petiole, preflowering period, thickness of the shell, thickness of the kernel and weight of kernel per nut were significantly, and directly correlated with the weight of copra per nut.

Characters like the number of leaves in the seedling, spathes per year, number of female flowers, number of nuts per year and percentage of set had a negative correlation with copra weight. Most of the growth characters showed positive correlation with the thickness of the kernel. Length of the petiole had positive significant correlation with several characters of economic importance (1) pre-flowering period (2) thickness of the kernel (3) weight of the kernel and (4) weight of the copra.

The longer petiole confers con committant advantage for several characters associated with positive attributes and so the

prevailing view needs revision. An interesting observation is that the correlated response at the parental level are shifted in the hybrids.

The F<sub>1</sub> advantage over parents is clearly evident in several cross combinations. In the three way and double crosses several combinations have given better performance for some growth characters. Three way and double cross hybrids mostly exhibited either female sterility or failure of nut development. Direct use of three way and double crosses in coconut seems to be limited.

427. LOUIS, I. HENRY. 1983. A variegated mutant in coconut palm. *Indian Cocon. J.* 14(5): 60. (Coconut Res. Centre, TNAU, Veppankulam, T.N.)

An interesting variegated variant of a dwarf palm was observed in Salem district of Tamil Nadu. Except the epicarp colour, the palm resembles a dwarf genesis type. In this mutant the green epicarp colour is replaced by white streaks. Running streaks are distinct even in the sepals and pitted with light yellow streaks. The petiole is also variegated like the epicarp.

428. LOUIS I. HENRY. and ANNAPAN, R.S. 1985. Observations on the seedling vigour in relation to the size and shape of seednut in Tall variety of coconut palm. *Indian Cocon. J.* 16(7): 5-11. (School of Genetics, TNAU, Coimbatore, T.N.)

Seed nuts of the cv. West Coast Tall were arranged in 10 groups according to size, shape, weight and several other character. Eleven nuts from each group were planted in the nursery and the following parameters were determined: germination percentage, mean seedling girth at collar, number of leaves, seedling height, percentage of seedlings with 6th leaf, and width of the 6th leaf in 9- and 12-month old seedlings. Irrespective of size and shape, nuts of low or medium weight had the highest germination

(99-100%). The mean collar girth was greatest (10.7 cm) in seedlings from egg shaped nuts weighing 960 g (group V), whereas seedling height at 9 months was greatest (92 cm) in seedlings from normal round uniform nuts weighing 1150.17 g (group VI). In 12-month-old seedlings the height was greatest (147 cm) in group VIII (medium uniform round nuts weighing 345.36 g). The highest percentage of 9-month-old seedlings with a 6th leaf occurred in groups I (small nuts with tapering ends weighing 654.18 g) and VI. Overall, the best results were gained with nuts from group VI.

429. LOUIS, I. HENRY. and CHELLADURAI, M. 1984. Nature and frequency of insects pollinating the coconut palm (*Cocos nucifera* L.). *Indian Cocon. J.* 15(8): 12-17 (Coconut Res. Station, TNAU, Veppankulam, T.N.)

During the distinct male and female phase it was found that the most frequent "pollinators" of the coconut palm were the honey bees viz., *Melipona tridipennis* Sm., *Apis cerana*, *Indica fabricus*, *Apis florea Fabricus*, flies like the *Bombus* species, (Bumble bees) and the two types of wasps viz., *Vespa orientalis*, and *Polistes herbracus* and the black-ant, *Camponotus compressus*. The frequency of their visit as well as the pollen and nectar gathering nature in the male and female phases of the inflorescence are described below.

430. LOUIS, I. HENRY. and CHIDAMBARAM. 1976. Inheritance studies on the phyllotaxy of coconut palm. *Ceylon Cocon. Q.* 27: (3-4) 22-24. (School of Genetics, TNAU, Coimbatore, T.N.)

Inheritance studies on two distinct types of phyllotaxy in coconut palm indicated that the F<sub>1</sub> segregated for left and right whorls in 1:1 ratio; irrespective of left x left, right x left, left x right and right x right combinations. Dominance of either character is ruled out. Asymmetry in coconut palm is decided entirely

by probability and does not appear to be controlled by genotypic difference nor does there seem to be cytoplasmic effect.

431. LOUIS, I. HENRY. and CHOPRA, V.K. 1988. Exploiting heterosis in coconut palms. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.6. (Regional Res. Station, TNAU, Paiyur, Coimbatore, T.N.).

Hybrid vigour was estimated in juvenile coconut palms through two separate experiments. Importance of exotic and indigenous coconut as parents in producing hybrids to achieve early germination and increased number of leaves per unit height was brought by the experiment. Intermediate values of seedling height with increased leaves in the hybrid indicate the potentiality for more leaves per unit height. Dwarf as female had significant effect on early germination and additive gene effects (Goa) for seedling girth height, and breadth of the laminate leaf. Additive and dominant gene action were true for increased number of leaves in the seedling.

432. LOUIS, I. HENRY. and CHOPRA, V.L. 1989. Genetic divergence in coconut (*Cocos nucifera* L.). In: Biological Approaches and Evolutionary Trends in Plants, International Symposium of Plant Bio-systematics, 4th, Tokyo, 1990. Proceedings of symposium. p.11-20. (School of Genetics, TNAU, Coimbatore, T.N.).

Genetic divergence using Mahalanobis  $D^2$  technique in 31 cultivars of exotic and indigenous origin was studied for 18 growth and reproductive characters. Cultivars differed significantly for the characters and could be grouped into 11 clusters. Major contributions to divergence were through the nut characters such as weight of kernel and thickness of the shell, kernel and husk. Among the growth characters, girth at collar of three year old seedling, its height and length of leaf, number

of leaflets in adult palm and the preflowering period were found important. Since cultivars from geographically different centres were found in the same cluster it is assumed that geographic origin of a cultivar need not necessarily relate to genetic divergence.

The pattern of clustering indicate that there is considerable genetic diversity in the material. At least three cultivars formed single number clusters, due to extreme divergence. There is no relationship between the genetic and geographic diversity in coconut.

433. LOUIS, I. HENRY. and CHOPRA, V.L. 1989. Selection index in coconut palm. *Philipp. J. of Cocon. Studies* 14(1): 10-13 (RARS, TNAU, Paiyur, T.N.)

Discriminant function was adopted to formulate selection index used in identifying two economic characters of coconut, namely, the number of nuts, and copra weight per nut against 17 common growth and reproductive characters. Three characters had common and positive role, and two had common but negative role in the selection for either the number of nuts or copra weight per nut. The number of leaves and height of the juvenile palm were treated as additional requisites, for identifying palm with increased number of nuts, while the thickness of kernel and shell served as additional characters for identifying palms with good copra weight. The expected genetic advances in selecting palms for the number of nuts and copra weight per nut through the selection index are 36.5% and 68.88% respectively. Index score was highest for ecotypes from the Philippines (San Ramon) and South America (San Blas) in both selections.

434. LOUIS, I. HENRY. and RAMACHANDRAN, T.K. 1981. Note on the oil content of some varieties of coconut palm. *Indian Cocon. J.* 12(5): 4-5. (RARS, TNAU, Veppankulam, T.N.).

Data on oil analysis of 23 genotypes are

analysed. Highest oil content of 77.22% on sanblas was recorded.

435. LOUIS, I. HENRY. and RATHNAKUMAR. L. 1988. Genetic load in coconut palm. *In*: National Symposium on Coconut Breeding and Management KAU, Vellanikkara, Trichur, Nov. 23-26, 1986. Abstracts of papers. p.8. (Regional Res. Station, Paiyur, TNAU, Coimbatore, T.N.).

Genetic polymorphism is common both in the selected and unselected coconut palms. Leaf mutants were observed in seedlings of tall and dwarf seedlings. It was less in hybrids. The rate of premature death was more in the parents and low in the hybrids. Though selection continuously removed the deleterious mutant genes in the population, linkage inversion and continuous mutation are assumed for building up and maintaining of heterozygosity within this limited genetic load in coconut.

436. LOUIS, I. HENRY, VIJAYAN, K.P.; PETER, S.D. and JAYARAMAN, C. 1977. A study on the variation in tender nut characters among coconut varieties. *J. Plantn Crops* 5(1): 59-60. (RARS, TNAU, Veppankulam, T.N.).

The non-reducing sugar content varied considerably (0.04 to 1.68%) in the varieties but the variation for total sugar content was only nominal. The volume of tender nut water showed almost four fold variation. A desired volume of water combined with high sugar content was observed in the varieties Semi-Tall Red and Semi Tall Green. The present results show the possibilities for selecting the character.

437. MANDAL, R.C. and MEHTA, G.M. 1984. Performance of coconut cultivar 'Benaulim' in Goa; a case study. *In*: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.61-65. (CPCRI, Kasaragod, Kerala).

'Benaulim', a local tall coconut cultivar of Goa is potentially a high yielder, but the productivity of coconut in Goa, in general, is low because of lack of irrigation, non-application of fertilizers and very close spacing. In a well-managed farmer's field, the variability in yield of individual palms was recorded, based on the previous thirteen years' production performance. The response to fertilizers and beneficial use of irrigation for increasing yield has been observed, and the economics of coconut cultivation worked out.

438. MATHAI, G. 1979. Adult performance of hybrids involving three varieties of coconut (*Cocos nucifera* L.) viz., Tall (Var. *typica* Nar.). Dwarf (Varhana Griff Nar.) and Semi-tall (Var *Javanica* Nar.) *Indian Cocon. J.* 9(11): 1-3 (Coconut Res. Station, KAU, Kumarakom, Kottayam, Kerala).

The adult performance of hybrids involving three varieties of coconut, *typica*, *jnana* and *Javanica* were studied under the conditons prevailing at the back water region of Kerala during the period 1971-1977. Observations on girth at collar, number of leaves produced, height and time of flowering indicated that Tall x Dwarf and Tall x Gangabondam which are crosses between widely different varieties exhibited hybrid vigour beyond the seedling stage. Among the two hybrids the amount of hybrid vigour exhibited by T x D was on par with Tall x Gangabondam in respect of girth at collar, number of leaves and height. With regard to the time of flowering Tall x Dwarf was found to flower earlier than Tall x Gangabondam. The Tall x Tall hybrid involving less diverse parental combinations expressed least vigour in the early periods of adult stage.

439. MATHEW, THOMAS and GOPIMONY, R. 1988. Heritability and correlations in West Coast Tall coconut palms. *In*: National Symposium on Coconut Breeding and Man-

agement, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.9 (College of Agric. KAU, Trivandrum 695 022, Kerala).

Seednuts collected from ten super mother palms and six sets of ordinary mother palms of West Coast Tall from southern districts of Kerala were sown in replicated progeny trial and seednut and seedling characters were observed. The heritability and coheritability (broad sense) of seednut and seedling characters and genotypic, phenotypic and environmental correlation between seedling character pairs were worked out following standard methods. Extremely high heritability estimate for weight of unhusked nut, husked nut and meat were obtained. Heritability estimates were medium to high for all the seedling characters. The coheritability for any two of these characters were also high. Highly significant positive genotypic correlations were obtained for most of the seedling character pairs, indicating predominance of additive gene action for the expression of those characters.

440. MATHEW, THOMAS., GOPIMONY, R. and GANGADHARAN, P. 1989. Evaluation of super mother palms of coconut by progeny analysis. *Agric. Res. J. Kerala* 22(2): 186-190. (College of Agric., KAU, Trivandrum 695 022, Kerala).

Seedling progeny analysis was conducted in super mother palms (yield not less than 300 nuts/year/tree). These were compared with control mother palms (annual yield not less than 80 nuts/year/palm). The objective was to evaluate these super palms for their pre-potent ability to produce quality seedlings.

441. MOHANDAS, C.; ANNIE, P.T. and PAVITHRAN, K. 1976. Anatomical studies on the bulbils of coconut. *Curr. Sci.* 45(8): 310-311. (Dept. of Botany, Calicut, Univ., Calicut, Kerala).

The anatomy of the bulbil, a thick fleshy globular tissues in one of the leaf bases of a

palm is described. The vascular bundles of the tissue are oriented irregularly and the parenchymatous cells are isodiameterical with the peripheral layers compressed. Interval tissue has tanniferous cells distributed all over and the globular structure is devoid of fibrous tissue unlike the normal leaf base.

Perhaps this abnormal structure is an axillary shoot/inflorescence included within the basal tissues of the leaf during ontogenesis, as a result of certain disharmony in growth.

442. NAIR, M.K.; NAMPOOTHIRI, K.U.K. and DAMODARAN, S. 1988. Coconut breeding, past achievements and future strategies. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.1. (CPCRI, Kasaragod, Kerala).*

Early efforts of coconut breeding in India included collection and conservation of germplasm initiated in 1930's which received further support of FAO/IBPGR during 1980's. The present Indian germplasm holding with 86 exotic and 41 indigenous accessions is one of the world's largest assemblage of the crop. Based on the evaluation of indigenous germplasm accessions, two cultivars viz., Laccadive Ordinary (Chandrakalpa) and Banawali Green Round have been released for cultivation.

Selection of the prepotent West Coast Tall palms based on progeny performance as well as identification of elite palms gave a new thrust to improve additional cultivars. The most significant impact was made by the advent of hybrid vigour in crosses involving tall and dwarfs.

443. NALLATHAMBI, H; RAVINDRAN, T.S. and VIJAYARAGHAVAN, A. 1986. Exploitation of heterosis for oil content in coconut (*Cocos nucifera* L.) *Indian Cocon. J.* 17(4): 3-4. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

This paper reports the results obtained from a study involving a set of six hybrids, their reciprocals and their seven parental genotypes for expression of hybrid vigour for oil content.

444. NAMPOOTHIRI, K.U.K. and NAIR, M.K. 1976. Superior planting material for garden land. *Indian Fmg* 25(11): 9-13 (CPCRI, (RC), Palode, Kerala).

Gives a brief description of promising selections and breeding programmes of coconut, arecanut, cacao and pepper.

445. NANDA KUMAR, T.B. 1987. A palm breeder on coconut improvement. *Indian Cocon. J.* 18(5): 11-15. (Coconut Development Board, Cochin, Kerala).

An interview with Shri K. Satyabalan, a formerly palm breeder of the CPCRI, Kasaragod. Contains his observations on selection of mother palm seednuts and seedlings.

446. NARAYANAN KUTTY, M.C. and GOPALAKRISHNAN, P.K. 1988. Yield components in coconut palms. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988.* p.11-12. (College of Hort., KAU, Trichur 680 654, Kerala).

A study on the morphological and chemical components of yield in coconut palms was conducted at the College of Horticulture, Vellanikkara, in order to characterise different yield groups based on these components, with a view of utilizing the information for identification of potential yielders.

Twenty coconut palms each under low, medium and high yield groups (<40 nuts/palm/year, 40-80 nuts/palm/year and >80 nuts/palm/year respectively) were selected for the study. Observations on morphological characters, mineral nutrients and bio-chemical constituents were recorded with yield. There was significant

positive correlation for the total number of leaves retained by the palm (0.693\*\*) and length of leaves (0.675\*\*) with yield. Among the mineral nutrients analysed nitrogen and potassium content in leaves had significant positive correlation with yield (0.417\*\* and 0.614\*\*). Significant positive correlation between total chlorophyll content and yield (0.631\*\*) and soluble sugars and yield (0.364\*\*) could also be observed. The total phenolic constituents exhibited a negative correlation with yield (-0.553\*\*). There was marked direct effect for leaf length, potassium content and chlorophyll content on yield. Yield prediction model using these characters with 74 per cent efficiency could be proposed.

447. NARAYANAN NAMBIAR, P.K. and RAO, G.S.L.H.V. PRASAD. 1986. Varietal and seasonal variations in the oil content of coconut. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988.* Abstracts of papers. p.43. (RARS, KAU, Pilicode, Kerala).

Of the three female parents WCT, LO and CDO, LO showed the maximum (73 per cent) oil content and the minimum by CDO (66 per cent). Among the male parents, WCT recorded the maximum (70.8 per cent) oil content, followed by LO (68.4 per cent) and GB (67.3 per cent). The percentage of oil content of the hybrids was intermediary.

The maximum oil content (72.8 per cent) was recorded during the post monsoon (October and November) followed by Winter (71.3 per cent) and the minimum (66.6 per cent) during the summer.

448. NELLIAT, E.V. 1983. Nutritional requirement of coconut genotypes. *South Indian Hort.* (Comm. iss): 109-113. (CPCRI, Kasaragod, Kerala).

Three high-yielding lines were grown without fertilizer and with total annual doses/

palm of 500:500:500 and 1000:1000:2000 g-N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O. Considerable variation in response to treatment was found. CDO x Tall was more productive than WCT x CDO and Tall under all treatments.

449. NINAN, C.A. 1976. Coconut breeding in India, achievements, lapses, problems and promises. *Cocon. Bull.* 7(6 & 7): 7-10. (Dept. of Botany, Univ. of Kerala, Trivandrum 695 581, Kerala).

Discussed the past achievements in coconut breeding research in India with emphasis on the advantages and disadvantages of the different hybrids produced.

450. NINAN, C.A. 1976. Selection and breeding dwarf coconut with special reference to Indian dwarf orange palms and their natural hybrids. *In: International Symposium on Coconut Research and Development, 1st, CPCRI, Kasaragod, Dec. 28-31, 1976. Abstracts of papers.* p.3. (Dept. of Botany, Univ. of Kerala, Trivandrum 695 581, Kerala).

The Dwarf Orange coconuts of the West Coast of India have long been known to produce a proportion of semi-tall progenies from seeds obtained after open pollination. They are believed to be products of outcross with Talls though they can be obtained after selfing Dwarfs also. Data are presented to show that such progenies are superior to West Coast Tall palms in yield of nuts, copra content per nut, and percentage of palms in high yielding group in different populations.

451. NINAN, C.A. 1978. Exploitation of Dwarf germplasm in coconut breeding. *Indian Cocon.* J. 8(11): 1-4. (Dept. of Botany, Univ. of Kerala, Trivandrum 695 581, Kerala).

Current research on coconut breeding in various countries are said to be centred around the Dwarf coconuts which possesses a number of forms and an adaptability for

varying degrees of self pollination and cross pollination.

Dwarf orange and Dwarf Green are two distinct forms among them. About 20% of the Orange Dwarf and 5% of the Green Dwarf will naturally be the off types when become adults, as crossed with Talls. With assisted pollination about 80% of the seedlings of Orange Dwarf turn out as D x T hybrids, the latter exhibiting considerable variation in vigour especially in the Chowghat Dwarf Orange variety. Hybrid-like progenies are also recovered when these Dwarfs are deliberately selfed. Some Dwarf mothers produce only pure Dwarf seedlings even when crossed with Talls. This shows pure Dwarf seedling has a necessity for selection of parent seed and seedlings. At present seed nut selection is not done in Dwarf as the natural hybrid production is satisfactory. A very small proportion of Dwarf Orange x Tall showed varying degrees of shades ranging from light bronze to green. Majority was having bronze petiole colour. Controlled crosses of the Dwarf Green with Talls and study of the resulting hybrids for yield and resistance to diseases would be of great value.

452. NINAN, C.A. 1982. Improvement of Dwarf coconut with special reference to Indian Dwarf Orange palms and their natural hybrids *Cocomunity APCC/QS 24(82):* 8-14. (Dept. of Botany, Univ. of Kerala, Trivandrum, Kerala).

Dwarf coconuts occur in most coconut growing countries of the world. The emphasis in coconut breeding throughout the world is presently centered around the Dwarfs. The main hope of coconut breeder in his efforts in breeding for improvement of yield, and perhaps also in his battle against diseases of unknown etiology, seems to lie in the efficient manipulation of the Dwarf germplasm. Its potentialities in coconut improvement are discussed in this paper with special reference to the dwarf orange coconuts of India.

453. PADMANABHAN, D. 1984. Ontogeny of plications in palm leaf - a new theory. *J. Swamy Bot. C.* 1(2): 59-67. (Dept. of Plant Morphology, Madurai Kamaraj Univ., Madurai 625 021. T.N.)

The inception of plications and the separation of leaflets in palm leaves is explained on the basis of vertical and transverse growth stresses (in the expanding and elongating lateral faces of the rachis) acting at the base of the nonplicate lamina which bears alternating lines of weaker parts between parallel rows of provascular strands whose cells elongate at right angles to the forces of vertical stress and resist them.

454. PADMANABHAN, D. 1985. New perspectives in the developmental morphology of the leaf *Cocos nucifera* L. In Symposium on Recent Advances in Developmental Morphology of Crop Palms, Dept. of Botany, APAU, Waltair, July 3-5, 1985. Proceedings of symposium. p.91-98. (Dept. of Plant Morphology, School of Biological Sciences, Madurai Kamaraj Univ., Madurai 625 021, T.N.).

The first report on a new theory which takes into consideration the hitherto neglected morphology of the rachis and the effect of vertical and horizontal growth stresses. The origin of plications is analysed on the basis of these new findings.

455. PANDA, K.C.; SASMAL, S. and SWAIN, J.N. 1986. A note on the performance of exotic varieties of coconut in Orissa. *Indian Cocon. J.* 16(7): 12-18. (Directorate of Agric. and Food Production, Bhubaneswar, Orissa).

Fifteen introduced exotic varieties of coconut were evaluated against the local cultivar at the Regional Coconut Research Station, Sakhigopal, Orissa. Various observations relating to flowering, yield and nut characteristics were recorded from 1958 to 1982. The data presented here show that the varieties like Java,

Laccadive Micro, Hybrid Tall x Dwarf, Cochin China and Philippines (Laguna) can profitably be popularised in the State. Possible significance of the results is discussed.

456. PETER, S.D., and JAYARAMAN, C. 1977. Variability for yield and quality of nuts in a population of East Coast Tall variety of coconut. *J. Plantn Crops* 5(1): 28-30. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Data are presented on the variation in yield, number of spathes, female flowers and nuts set, and nut characteristics within a single population of East Coast Tall Coconuts measured in 1971 and 1975. The need to take both nut production and quality into consideration when selecting mother palms is stressed.

457. PILLAI, R.V. 1985. Seed multiplication for coconut role of private sector. In: National Symposium on Oilseed Production and Utilization - Constraints and Opportunities, New Delhi, Sep. 1984. Proceedings of the symposium. Edited by H.L. Srivastava and others. New Delhi, Oxford and IBH. p.563-567. (CPCRI, Kasaragod, Kerala).

The need for improved seed requirements with regard to coconut and the research efforts to supplement this are mentioned in the article. The world acreage, production and productivity as well as the area and production of coconut in India are tabulated. Constraints in increased productivity and the improved methods of seed production including the usage of pollen applicator developed by CPCRI for hybridisation are outlined. Emphasis is also given to private sector in establishing seed gardens to provide planting material.

458. PILLAI, R.V.; RAO, E.V.V. BHASKARA and KUMARAN, P.M. 1988. Characterisation of coconut cultivars. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Ab-

stracts of papers. p.7. (CPCRI, Kasaragod, Kerala).

The coconut germplasm collection at the Central Plantation Crops Research Institute consists of 62 exotic and 35 indigenous collections at the World Coconut Germplasm Centre, Sipighat, Andaman. This is the largest collection available anywhere in the world, comprising representative samples from geographically divergent population. Basically there are only two distinct varieties in coconut the Tall and the Dwarf. While the tall was extensively cultivated, the dwarf was grown only as an ornamental type till recently when their value as parents in the hybrid production was established, for the purpose of preparing the descriptor. The identity of the individual introduction is maintained and it is considered as a separate accession because of the lack of reliable classification criteria. A suitable descriptor for coconut is still not available and hence even experienced coconut breeders find it difficult to identify even the cultivars. Since most of the phenotypic characters useful in the identification of the cultivar are polygenic, a clear-cut demarcation is rather difficult in the identification. A model descriptor developed by this institute was taken as a basic document in the preparation of the descriptor, by the Coconut Breeders' Consultation Group of IBPGR. This descriptor is being used in this paper for characterising 18 genotypes of coconut comprising 14 tall and 4 dwarf and the data was analysed in a computer. Fruit component analysis as well as other measurable phenotypic characters have been used in developing this descriptor for the characterisation.

459. POTTU, N.N.; NAIK, B.J.; RAJAMONY, L. and NAMBIAR, P.K.R. 1980. Comparative performance of eight coconut varieties in red loam soil. *Indian Cocon. J.* 11(5): 1-2. (Coconut Res. Station, KAU, Pilicode, Kerala).

West Coast Tall, local variety, was superior to two other local and five exotic varieties

in number of bunches, suggested that genotype-environmental interaction reduced setting percentage in Andaman Ordinary and Laccadive ordinary and reduced female flower production in Laccadive Micro and Laccadive Small, while both characters were affected in Bombay and Cochin China.

460. PUSHKARAN, K. and GEORGE, T.E. 1980. A highly vigorous abnormal male coconut palm. *Indian Cocon. J.* 20(12): 8-9. (Banana Res. Station, KAU, Kannara 680 652, Kerala).

One exceptionally robust palm bearing male flower was noted in a plantation of 700 palms at Kannara. It is described with tabulated data on its height, stem girth, leaf number, leaf length, and pollen fertility compared with those for an average monocious palm. The height of an average palm was 8.3 m and that of male palm was 13.7 m. The average pollen fertility was 79.2 and 78.6% respectively.

461. RAMACHANDRAN, M.; MURALIDHARAN, V.N. and BALASUBRAMANIAN, K. 1977. A note on the new coconut variety Ayiramkachi. *Indian Cocon. J.* 8(4): 4-6. (Sugarcane Experiment Substation, Songumani, Trichy, T.N.).

Comparative morphological and yield data are tabulated for the new variety and three others. Ayiramkachi is described and illustrated; it is generally intermediate between tall and dwarf coconut varieties.

462. RAMADASAN, A.; KASTURIBAI, K.V.; SHIVASHANKAR, S. and VIJAYAKUMAR, K. 1985. Heritability of seedling vigour in coconut palm. *J. Plantn Crops* 13(2): 186-188 (CPCRI, Kasaragod, Kerala).

Forty adult West Coast Tall (WCT) palms were tested for their seedling vigour by means of girth at collar, height and number of leaves. The heritability values together with the mean and range values of the characters have been studied and tabulated. Results indicated that

the girth at collar is mostly contributed to seedling vigour thus suggesting, choosing girth at collar alone as seedling selection character is worth exploring.

463. RAMADASAN, A. and SATHEESAN, K.V. 1980. Certain leaf anatomical characteristics of two coconut cultivars and hybrids. *J. Plantn Crops* 8(1): 55-57 (CPCRI, Kasaragod, Kerala).

Young palms of the *Cocos nucifera* cultivars West Coast Tall (WCT) and Chowghat Dwarf Green (CDG) and the hybrids WCT x CDG and reciprocal and WCT x Gangabondam which is a semitall cultivar, were examined for leaf thickness and tissue density. Leaves of WCT contained more air space volume than those of CDG or the hybrids and thus although WCT has higher leaf thickness, it has got less tissue density. Thus coconut leaf possesses less photosynthetic efficiency than seen in  $C_4$  species.

464. RAMANATHAN, T. 1982. Clones in seed propagated coconut. *Kisan Wld* 9(5): 32-33. (School of Genetics, TNAU, Coimbatore, T.N.).

The author during his field visit at Koilur near Muthupet in Thanjavur District has observed an abnormal Coconut palm in 30 year old plantation. In the abnormal coconut palm, the spadices, spikes, female flowers and even the male flowers were found to be transformed into vegetative shoot described as 'bulbil shoots'. The bulbil shoots which are developing from the axils of leaves resembled young spadices. But as they enlarged, their flower bearing spikes got suppressed, instead, the development of the subtending bracts got stimulated into large spathes which progressively transformed into pinnate leaves, the shoot ultimately developing into a 'seedling'. Attempts were made to induce roots in the bulbils by separating them from the mother palm and planting them in pots filled with garden soil compost mixture at Coconut Research Station, Veppankulam which proved futile.

465. RAMANATHAN, T. 1984. Character association in coconut. *Madras Agric. J.* 71(3): 191-192. (School of Genetics, TNAU, Coimbatore, T.N.).

Observations were recorded on eight characters and correlated with yield. The data have shown that number of leaflets, total number of leaves, girth of stem at base, length of leaf and girth of stem at crown were found to be positively and significantly correlated with yield in the order mentioned. High degree of positive association was observed between height of stem, on the one hand, and total number of leaves and girth of stem at base on the other. Stem height was also found to be positively related to number of functional leaves, length of leaf, number of leaflets and breadth of leaf in the order mentioned.

466. RAMANATHAN, T. 1984. Path co-efficient analysis for yield in East Coast Tall coconut. In: Symposium on Plantation Crops, 6th RRII, Kottayam Dec. 16-20, 1984. Proceedings of PLACROSYM VI. Edited by M.R. Sethuraj and others. p.23-29. (School of Genetics, TNAU, Coimbatore, T.N.).

Path co-efficient analysis was carried out in population of East Coast Tall cultivar of coconut to identify character which have direct and indirect influences on yield. Among the 12 characters studied, positive direct effects of number of functional leaves, number of bunches with nuts and number of leaflets on yield indicate the importance of these characters in selection programme in East Coast Tall Coconut.

467. RAMANATHAN, T. 1987. Association of seednut weight with seedling characters in coconut. *Indian Cocon. J.* 18(4): 3-4. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

The data indicated that in ECT x Ayiramkachi hybrid, seednut weight is found to be associated with seedling weight whereas

in ECTx MDG seednut weight, girth at collar and weight of the seedling are associated ECT and ECT x MDG did not show any correlation between seednut and weight. Thus the seedling characters are influenced by the genetic make-up of the parents and the characters differ as per the parent.

468. RAMANATHAN, T. 1989. Heterosis breeding in coconut. *Cocos nucifera* L. *Indian Cocon. J.* 19(10): 5-10. (RARS, TNAU, Veppankulam, T.N.).

Utilising the traditionally grown ECT as female parent, three sets of coconut hybrids namely ECT x Ayiramkachi, ECT x MGD and ECT x MYD reciprocal were studied. Heterosis for 11 characters 6 hybrids and 2 parents were studied and the details presented in the paper.

469. RAMANATHAN, T. 1989. Parent progeny analysis for nut yield in East Coast Tall. *Indian Cocon. J.* 20(4): 3-4. (RARS, TNAU, Veppankulam, T.N.).

This was a study conducted to assess the prepotency in ECT coconut. One among the 10 mother palms chosen for the study was found to be the best pre-potent palm.

470. RAMANATHAN, T. and LOUIS, I. HENRY. 1983. Heterosis in coconut. In: Genetics and improvement of heterotic systems, pre-congress scientific meeting of international conference of genetics, 15th, New Delhi, Dec. 7-9, 1983. p.16. (School of Genetics, TNAU, Coimbatore, T.N.).

The expression of heterosis in three sets of Tall x Dwarf hybrids and a reciprocal hybrid was studied with reference to morphological characters and yielding ability.

471. RAMANATHAN, T., LOUIS, I. HENRY. and NAVAKODI, K. 1982. High yielding VHC-1 coconut hybrid. In: Symposium on Plantation crops, 5th, CPCRI, Kasaragod, Dec. 12-15, 1982. Proceedings of PLACROSYM V. Edited by K.V.A.

Bavappa and others. p.125-130. (School of Genetics, TNAU, Coimbatore, T.N.).

A study on the performance of certain intervarietal hybrids in coconut has shown that East Coast Tall x Dwarf Green is most promising in yield of nuts, copra and oil content. The importance of choice of parental palms in both Tall and Dwarf varieties was evident from the expression of heterosis in a few parental combinations. With a view to exploiting heterosis to step up coconut production, hybridization was repeated with such of those parental combinations which exhibited superior performance. As a result, VHC 1 (Veppankulam Hybrid Coconut-1) was released during 1982 for commercial cultivation.

472. RAMANATHAN, T., and NALLATHAMBI, G. 1988. Performance of unirrigated East Coast Tall x Dwarf Green and East Coast Tall x Chowghat Dwarf Orange coconut hybrids. *Indian Cocon. J.* 18(12): 3-5 (Coconut Res. Station, TNAU, Veppankulam T.N.).

This article enumerates the relative performance of East Coast Tall x Dwarf Green and East Coast Tall x Chowghat Dwarf Orange. Results revealed that hybrid ECT x DG out yielded ECT x COD and ECT. Average nut production recorded was 76 per palm/annum in case of ECT x DG whereas it was 32 and 24 in case of ECT x COD and ECT respectively.

473. RAO, E.V.V. BHASKARA and KOSHY, P.K. 1981. Coconut germplasm collection in Pacific Ocean Islands. Deputation report. 47p. (CPCRI, Kasaragod, Kerala).

An attempt was made to solve the problem of root(wilt) disease in India by introducing cultivars from Pacific Ocean Islands which are known to have the highest variabilities. This mission was undertaken by the CPCRI (India) with financial assistance from the International Board for Plant Genetic Resources, FAO. Information for nuts collected from 21

sites are recorded.

474. RAO, E.V.V. BHASKARA and MATHEW, JACOB. 1981. An index forevaluation of coconut germplasm in the nursery. *In: Symposium on Plantation Crops, 4th Mysore, Dec. 3-5, 1981. Proceedings of PLACROSYM IV. Edited by S. Vishveshwara and others. p.200-205. (CPCRI, Kasaragod, Kerala).*

Data were recorded on 7 traits 12 months after germination in at least ten seedlings of each of 21 cultivars. Cultivars were assessed using indices based on mean values and co-efficients of variation for each character.

475. RAO, E.V.V. BHASKHARA and PILLAI, R.V. Characterization of coconut germplasm based on fruit component analysis. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 12-15, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.112-124. (CPCRI, Kasaragod, Kerala).*

The coconut germplasm collection at the Central Plantation Crops Research Institute consists of 62 exotic and 32 indigenous accessions. It is by far the largest collection available anywhere in the world, comprising representative samples from geographically divergent populations. The germplasm collection is divided into four major geographical sets based on the location of collection, namely, accessions from countries in South East Asia, Pacific Islands, North Central and South-American, and African region. Data on yield and nut characters in 40 accessions are presented in this paper. The annual out-turn of copra ranged from 7 to 30 kg/palm/year in Tall cultivars while in the Dwarfs it was less than 10 kg/palm/year. The classification system based on fruit component analysis, and the time taken for germination, has been adopted to identify the degree of introgression in different accessions. Priority areas for future collections are also discussed.

476. RAO, E.V.V. BHASKARA; PILLAI, R.V. and MATHEW, JACOB. 1988. Relative drought tolerance and productivity of released coconut hybrids. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Nov. 23-26, 1988. Abstracts of papers. p.20. (CPCRI, Kasaragod, Kerala).*

Eightyseven coconut hybrids comprising of 21 different Tall x Dwarf, 10 Dwarf x Tall, 51 Tall x Talls, 4 Dwarf x Dwarfs and one three way hybrid were studied. Evaluation at 18th year based on cumulative yield which was representative of true yield potential, was carried out and three hybrid combinations namely, Chandrasankara (CDO x WCT), Chandralaksha (LO x CDO) and Lakshanganga (LO x GB) were identified as superior hybrid combination and released for Kerala. These hybrid combinations gave 19 to 42% more yield over the commonly cultivated WCT. Among these three hybrids, Chandrasankara (CDO x WCT) was found to give 47% higher copra over WCT. Hybrids Lakshaganga (LO x GB) and Chandraleksha (LO x CDO) performed well under drought situations. The drought tolerance in these hybrids was identified to be the contribution from the female parent Lakshadweep Ordinary. The performance of these three hybrids in relation to other hybrid combinations and drought situation is discussed.

477. RAO, G.S.L.H.V. PRASADA and NAIR, R.R. 1989. Influence of weather on nut development in coconut. *J. Plantn Crops* 16(Suppl.): 469-473 (RARS, KAU, Pilicode, Kerala).

The monthly variation in nut development of 3 hybrids was studied in 1985-1986. The mean dehusked nut weight of hybrid CDO x T was higher (538 g/nut) than that of hybrids T x CDO (498 g) and CDO x LO (504 g/nut), but T x CDO had the highest copra content (149 g/nut). All 3 hybrids showed the highest copra content in nuts harvested in summer (Mar-May). The second phase of nut development (5-8 months after flower fertilization)

was strongly, influenced by total heat units, where a heat unit is equivalent to  $1/2 \times$  (maximum temperature in °C + minimum temperature in °C) minus 10°C. A quadratic regression equation relating nut weight to total heat units during the second phase of nut development was developed. The multiple correlation coefficients were 0.8689 for CDO x T, 0.8443 for T x CDO and 0.7977 for CDO x LO.

478. RAVEENDRA, T.S.; RAMANATHAN, T.; NALLATHAMBI, G. and VIJAYARAGHAVAN, H. 1987. Metroglyph analysis in coconut (*Cocos nucifera* L.). *Cocos* 5: 32-38. (Coconut Res. Station, TNAU, Veppankulam 614 906, T.N.).

Metroglyph analysis was done in a group of 23 genotypes of coconut. The varieties came under two groups based on morphological characters. These groups were recognised when the classification was made on the basis of nut characters. The exotic cultivars, in general, had relatively higher expression for morphological and nut characters. The possibility of obtaining heterotic hybrids from divergent parental combinations was indicated.

479. SATYABALAN, K. 1976. Coconut hybrids. *Indian Fmg* 27(9): 13-16. (CPCRI, Kasaragod, Kerala).

Characteristics of hybrids between Tall and Dwarf varieties are described. Dwarf Orange has been found better than Dwarf Green as the male parent of nuts with less fibre and more copra than crosses involving Dwarf Green. The hybrids West Coast Tall x Dwarf Orange and West Coast Tall x Gangabondam (green dwarf) have shown heterosis for weight of husked nut and water and kernel content of the nuts.

480. SATYABALAN, K. 1982. Need for selection among the parents in the production of Dwarf x Tall coconut hybrids. *Cocomunity APCC/QS/40/82*: 1-9. (CPCRI, Kasaragod, Kerala).

The data on the nut and copra characters of the parents and hybrids in coconut reported by different workers from different countries like India, Ivory Coast, Malaysia and Jamaica presented indicate that there is wide variation between them. Though Malayan Dwarf is grown in countries like Ivory Coast, Malaysia, Jamaica etc. their nut and copra characters differ from country to country and even within a country. Similarly, the local tall and dwarf cultivars grown in different countries also differ in their nut characters. Therefore the performance of the hybrids produced in different countries is likely to vary depending on the combining ability of the parents used in these crosses. In a promising hybrid both the yield of nuts and the copra content per nut should be high resulting in high copra out turn when compared to those of the local cultivar. To produce such a hybrid, parent palms among the tall and dwarfs available in a country should be selected for making crosses to obtain promising parental combinations. If such parental combinations are not identified, the hybrids produced may not turn out to be promising as they will not be superior to the local tall cultivar in their performance.

481. SATYABALAN, K. 1982. The present status of coconut breeding in India. *J. Plantn Crops* 10(2): 67-80. (CPCRI, Kasaragod, Kerala).

The progress in the research work done on collection, conservation and evaluation of coconut germplasm and in selection and hybridization for the improvement of the palm in the different research centres in India since 1970 is reviewed. Limitations met with in coconut breeding are enumerated.

482. SATYABALAN, K. 1982. Yield capacity and transmitting power of mother palms in coconut. *Indian Cocon. J.* 13(4): 5-13. (CPCRI, Kasaragod, Kerala).

The tall variety of the coconut palm is

the one that is most extensively cultivated on a plantation scale in all the crop producing countries in the world. It is a highly heterozygous crop with pan tropical distribution. Because, it is largely cross pollinated in nature, considerable variability occurs within the tall variety itself forming diverse pan mitotic population.

483. SATYABALAN, K. 1983. Age of seedlings at transplanting in coconut. *J. Plantn Crops* 11(1): 13-20. (CPCRI, Kasaragod, Kerala).

The age of coconut seedling at transplanting varies in different countries according to the prevailing practices and other conditions. It depends mainly on the ecological and climatic conditions in different countries. The advantages and disadvantage of planting younger/older seedlings in the main field are discussed. Research workers on coconut should consider and study all these aspects and recommend suitable practices to the farmers so that the time lag between planting and flowering of the seedling as a result of transplanting shock is reduced to the minimum which will be of immense benefit to farmers of this economically important perennial crop.

484. SATYABALAN, K. 1983. Nursery studies in West Coast Tall coconut; 1. germination of seednuts harvested during January to May. *Indian Cocon. J.* 14(6): 3-10. (CPCRI, Kasaragod, Kerala).

Long term nursery studies on the germination of West Coast Tall seed coconuts harvested during January to May and planted in the nursery in June or July indicate the germination trend of seed coconut harvested during the different months. The studies brought out the following. 1. On the West Coast, January to April is the best period for collection of seednuts. 2. There is not much difference in the germination rate between June and July sowing. 3. January nuts are to be preferred to May nuts for seednut purposes. 4. For

studies on germination it is advisable to slow the seednuts of different harvests separately and record the germination date of each nut till December in June and July sowings since more than 90 per cent of the seednuts would have germinated by December.

485. SATYABALAN, K. 1984. Genetic improvement of coconut palm. *Indian Cocon. J.* 15(34): 3-11. (Ananda Vilas, North Parur 683 513, Kerala).

Constraints faced by scientists in the production of improved planting material in coconut plams and possible means of overcoming such constraints are discussed. High yielding ability of a palm mainly depends on its genetical constitution. Thus identification of prepotent palms is of major importance in both mother palm selection and production of hybrids. In hybridization practices progeny depends on the combining ability of parents. Heritability values for yield, copra out turn/nut and weight/husked nut are 0.5, 0.67 and 0.97 respectively, and hence prepotent palms should be selected on the basis of regularity for these characters which is no doubt time consuming and a work of generations but still worth attempting. Collar girth and leaf production are 2 reliable characters usable in identifying genetically superior planting material at the seedling stage.

486. SATYABALAN, K. 1984. Nursery studies on West Coast Tall coconut to select seedlings for early transplanting. *J. Plantn Crops* 12(2): 112-118. (Anandavilas, North Parur, 685 513, Kerala).

Possibility of selecting West Coast Tall coconut seedlings at the fifth month itself in the nursery has been indicated based on the high and positive correlation of growth characters like collar girth and leaf production from the fifth month after germination with those of the later months. Studies on the rate of growth of seedlings in respect of collar girth

and leaf production indicated that the growth rate which was high in the beginning decreased slowly till the sixth month and thereafter increased gradually. This could be attributed to the utilization of endosperm by the seedling till the sixth month and thereafter a gradual change over to full dependence on photosynthesis. Selection of seedlings at early stage in the nursery reduce the setback in growth immediately after transplantation.

**487. SATYABALAN, K. 1984.** Nursery studies in West Coast Tall coconut; 2. Seedlings growth and output of quality seedlings in seednuts germinated during different months. *Indian Cocon. J.* 14(12): 3-11. (CPCRI, Kasaragod, Kerala).

Studies on growth characters like collar girth and leaf production in seedlings from seednuts sown in June or July but germinated during different months indicate that there is slight difference between them which leaves one to doubt whether selection of seedlings in West Coast Tall is effective in improving the yield. The output of quality seedlings will be high if the seedlings are studied for their growth characters from the time of germination of each seednut whether they are sown in June or July depending on the onset of the South West monsoon in the West Coast of India.

**488. SATYABALAN, K. 1985.** Nursery studies in West Coast Tall coconut; 3. germination, seedling growth and output of quality seedlings in relation to storage period of seednuts. *Indian Cocon. J.* 16(4): 3-9. (Anand Vilas, North Parur, 683 513, Kerala).

Studies on germination, seedling growth and output of quality seedlings in relation to storage period of seednuts of West Coast Tall coconut harvested during January to May have indicated that the quality of seednuts at the time of harvest and weather conditions during germination and development of the seedlings rather than storage period largely account for

the variation in germination, growth of the seedlings and recovery of seedlings of vigorous growth characters. Hence on the West Coast of India seednuts harvested during the summer months may be stored and planted in the nursery during the onset of the South West Monsoon in June or July to obtain maximum germination and a high percentage of recovery of quality seedlings.

**489. SATYABALAN, K. 1985.** Growth and yield performance of West Coast Tall seedlings germinated during different months (August to October) on the West Coast of India. *Indian Cocon. J.* 15(11): 3-9. (Anand Vilas, North Parur 683 513, Kerala).

Studies were carried out on the growth and yield performance of West Coast Tall seedlings germinated during different months (August to October) on the West Coast of India have indicated that 1) There was very little difference in the rate of leaf production from the time of germination in the nursery in the seedlings germinated during August to October. 2) There was not much difference in the rate of leaf production per year during a period of ten years after transplanting in the field in the seedlings germinated during August and September. But seedlings germinated in October recorded a high rate of leaf production only during fifth to seventh year after transplanting and afterwards the rate of leaf production was similar to those in the other two groups. The total number of leaves produced from the time of germination was more in October germinated seedlings than in the other two groups. 3). The time of germination had no influence on the height of the seedlings, attained during a period of 26 years after transplanting and 4) There was no significant difference in the mean yield of nuts of the seedling in the three groups. But the cumulative yield per palm was more in September and October germinated seedlings

than in August germinated ones.

It is evident from these studies that if the seedlings are measured for their growth characters from the time of germination to a particular period, there may not be much difference between them; whether they germinate early or late and their mean yield difference may not be significant. Hence early germination cannot be considered as an important criterion for selection of seedlings.

490. SATYABALAN, K. 1986. A study on the growth and yield of underplanted West Coast Tall coconut palms in Kerala. *Indian Cocon. J.* 16(10): 3-9. (Anand Vilas, North Parur 683 513, Kerala).

A study on the growth and yield of West Coast Tall coconut palms underplanted early in a garden wherein the palms have not attained senility has indicated the need to avert the setbacks in growth by underplanting at the proper time when the palms in the garden attain senility with proper spacing to avoid the shade and root effects of the neighbouring palms and by paying attention to other problems which require special consideration in underplanting. It is better to consider these problems when underplanting or replanting diseased palms under the Coconut Replanting Project in Kerala, so that the planted seedlings may bear early and turn out to be more productive and maintain high level of production in the subsequent period.

491. SATYABALAN, K. 1989. Coconut. In: Oil crops of the world; their breeding and utilization. Edited by G Robbelen and others. New York: Mc GrawHill. p.495-504. (Ananda Vilas, North Parur 683 513, Kerala).

Importance and distribution, Origin and systematics. Mode of reproduction, Breeding procedures, Collection, conservation and evaluation of germplasm, Selection, Hybridiza-

tion: Breeding objectives, History of cultivar development and Utilization of products are the subjects dealt with in this chapter.

492. SATYABALAN, K. 1990. Early germination and seedling selection in coconut. *Indian Cocon. J.* 29(11): 2-6. (Ananda Vilas, North Parur 683 513, Kerala).

Studies were carried out on the germination and growth of seedlings germinated between July and Nov. from seednuts harvested between Jan. and May, and on the growth characters of seedlings from seednuts sown in June. Also determined were leaf production, palm height, and yield of palms raised from seednuts germinated during Aug., Sep. or Oct. No great variation was observed in the parameters studied, and it is suggested that early germination is not an important criterion for the selection of West Coast Tall seedlings in the nursery.

493. SATYABALAN, K. and MATHEW, JACOB. 1983. Identification of prepotent palms in West Coast Tall coconut based on the early stages of growth of the progeny in the nursery. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976. Edited by N.M. Nayar. New Delhi: Wiley Eastern. p.15-22. (CPCRI, Kasaragod, Kerala).

Monthly observations on growth rate and seedling vigour as measured by collar girth and leaf production from the time of germination taken in 599 open pollinated progeny seedlings of 16 selected high yielding families (Cultivar - West Coast Tall) indicated highly significant differences in growth rate of progenies between families. Correlations of these growth characters from the first to ninth month from the time of germination with those of the tenth month showed that correlation was high and positive from the fifth month. This shows that it may be possible to identify palms of superior genetic

value (prepotent) even from the fifth month based on these two growth characters of the progeny.

The breeding values of six families worked out for leaf production and collar girth of the progeny during the fifth and tenth months of growth in the nursery and their yield period in the field showed that prepotent palms, whose progenies would be high yielders, have high breeding values for both these characters. Thus it may be possible to screen a large number of palms for prepotency and identify them based on these growth characters of the progenies in the nursery during the fifth month of growth. In areas where young seedlings of less than six months old are preferred for planting, it is better to select them from five months old seedlings based on these two characters as they are genetically correlated with yield of adult palms.

494. SATYABALAN, K. and MATHEW, JACOB. 1984. Correlation studies on the nut and copra characters of West Coast Tall coconut harvested during different months of the year. *J. Plantn Crops* 12(1): 17-22. (CPCRI, Kasaragod, Kerala).

There were significant correlations between (1) weight of fruit (unhusked) and weight of husked nut, (2) weight of fruit and that of the husk, (3) weight of husked nut and fresh weight of kernel, (4) weight of husked nut and fresh weight of shell, (5) weight of husked nut and weight of copra, (6) fresh weight of kernel and weight of copra and (7) weight of shell and weight of copra in the nuts harvested during different months of the year. Some slight differences in the indices studied were attributed to seasonal effect during fruit development.

495. SATYABALAN, K. and PILLAI, R.V. 1977. Yield performance and nut and copra characters of eight germplasm introduction of coconut. *Indian J. Agric. Sci.* 47(9): 430-434.

(CPCRI, Kasaragod, Kerala).

Seed material from many coconut-growing areas of the world was planted in 1955-56 for assessment of performance under local conditions. Data were tabulated on the following: number of spathes, number of female flowers; setting percentage; yield of nuts; mean copra yield/nut; annual copra production/palm; percentage of oil in copra; number of nuts required for a tonne of copra; fruit weight; husked nut weight; percentage of water in husked nut; kernel percentage in husked nut; shell percentage in husked nut; and copra percentage in husked nut. The cvs Zanzibar, British Solomon Islands and West Coast Tall (standard c.v.) were noted for high nut yield and San Ramon, Zanzibar, Guam and again West Coast Tall were noted for high copra production. The other cvs studied were Borneo, Seychelles, Kenya and Jamaica.

496. SATYABALAN, K. and RAJAGOPAL, K. 1983. The Malayan Dwarf Coconut. *Indian Cocon. J.* 13(12): 11-21. (CPCRI, Kasaragod, Kerala).

Studies on the yield performance and fruit analysis of green, yellow and red forms of Malayan Dwarf and of green and orange forms of Chowghat Dwarf indicate that Chowghat Dwarf. Nut and copra characters of Malayan Dwarf is different from Malayan Dwarf yellow and red form studied and those reported from other countries show considerable variation between them. Nut and copra characters of individual palms of Malayan Dwarf yellow studied also show variation between palms. On the basis of fruit analysis, the palms of Malayan Dwarf yellow have been classified into four groups. The variation between palms is likely to result in the variable performance of Dwarf x Tall hybrids produced from them.

497. SATYABALAN, K. and RAJAGOPAL, K. 1985. Genetic improvement of the coconut

palm prepotency studies. *J. Plantn Crops* 13(2): 125-131. (Anand Vilas, North Parur, 685 613, Kerala).

Seedlings of eight combinations of Dwarf female x Tall male obtained from crosses between five Dwarf genotypes and three Tall genotypes were studied to identify the parental combination which would yield maximum number of hybrids. The palms were selected on the basis of nut characters like shell and copra content in the husked nuts of dwarf palms and husk and copra content in the fruits of tall palms. The seedlings obtained from these combinations were scored for heterotic hybrids on the basis of petiole colour and vigorous growth of the seedlings in the nursery. The study has indicated that to obtain maximum number of hybrid seedlings, it is preferable to select dwarf palms which yield nuts having a low shell content (less than 20 per cent of husked nut weight) as pistillate parents and tall palms which yield nuts which have less husk content (less than 50 percent of the weight of fruit) and a high copra content per nut (above 150 gm per nut) as pollen parents. It may be possible to identify individual palms in both the parents which when combined may yield a large number of hybrid seedlings. Seedlings of the best combinations should be utilized for laying out hybrid seed gardens for large scale production of hybrids.

498. SATYABALAN, K. and RAJAGOPAL, K. 1987. Genetic improvement of the coconut palm combining ability of palms in Dwarf x Tall hybrids. *J. Plantn Crops* 15(1): 23-30. (Anand Vilas, North Parur, 685 513, Kerala.)

Seedlings of 8 combinations of Dwarf female x Tall male obtained from crosses between 5 dwarf genotypes and 3 Tall genotypes were studied to identify the parental combination which would yield maximum number of hybrids. The study has indicated that to obtain maximum number of hybrid

seedlings it is preferable to select dwarf palms which yield nuts having low shell content as pistillate parents and Tall palms which yield nuts which have less husk content and a high copra content pre nut as pollen parents.

499. SATYABALAN, K. and VIJAYAKUMAR, G. 1982. Comparative performance of progenies from Chowghat Dwarf Orange coconut. In: Symposium on Plantation Crops, 4th, Mysore, Dec. 3-5, 1981. Proceedings of PLACROSYM IV. Edited by S. Vishveshwara and others. p.289-294. (CPCRI, Kasaragod, Kerala).

Seedlings were selected for vigour from populations obtained by (1) open pollination (unemasculated), (2) selfing (unemasculated), (3) hybridization with West Coast Tall (emasculated) and (4) open pollination (emasculated) and were planted in 1966. In 1976-79, seedlings obtained by method (3) gave the highest cumulative and annual yield, closely followed by those obtained by (2). Mean copra outturn and oil content were highest in those obtained by (2) followed by those obtained by (3).

500. SHAMSUDDIN, V. M. and NAMBOODIRI, K.M.N. 1979. Variation in pollen characteristics of eight coconut cultivars; *J. Plantn Crops* 7(1): 61-62. (Agric. College and Res. Institute, KAU, Trivandrum 695 022, Kerala).

Studies on pollen and pollen germination characteristics were carried out using eight coconut cultivars. Pollen fertility was studied adopting acetocarmine staining technique. Pollen grains were germinated in a specified agar + gelatin medium and observed. After allowing for germination at room temperature, pollen grains were fixed in Carnoy's fluid. Germination percentage of each cultivar was worked out and pollen tube length was measured. Results showed that there is no significant variation in stainability and pollen diameter of each cultivar although a considerable variation in pollen diameter and pollen tube

length is seen. This gives off the sense of a certain variation in nutritional and environmental requirements for pollen germination in different cultivars.

501. SHANTHAMALLAIAH, N.R., GOWDA, T.N., KRISHNA MANOHAR, R. and BALAKRISHNA, P. 1981. Growth of yield performance of coconut germplasm collection at Agricultural Research Station, Arsikere (Karnataka). *In: Symposium on Plantation Crops, 4th, CFTRI, Mysore, Dec. 3-5, 1981. Proceedings of PLACROSYM IV.* Edited by S. Vishveshwara and others. p.224-228. (Agric. Res. Station, Arsikere, Karnataka).

Nineteen germplasm collections (both exotic and indigenous) were made for adaptive trials at the agricultural Research Station, Arsikere (Karnataka). They were collected from the Central Plantation Crops Research Institute, Kasaragod, Kayangulam and Pilicode Research Institute, of Kerala State. Observations on growth and yield performance were recorded from the beginning of their planting. Data so collected and the results obtained of their performances for the last four years are presented and discussed in this paper.

502. SHYLARAJ, K.S.; BINDU, M., GOPAKUMAR, K. and GOPIMONY, R. 1988. Comparing Komadan coconut type with West Coast Tall. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers p.9-10.* (College of Agric., KAU, Trivandrum 695 022, Kerala).

Komadan, a local coconut ecotype popular in parts of Pathanamthitta district of Kerala is compared with West Coast Tall (WCT) cultivar through estimation of mean and variance of mother palm, seednut and seedling characters. Forty Komadan Palms available in the Instructional Farm, College of Agriculture, Vellayani and fifty WCT palms of the same age group and belonging to the highest yield range

available in the coconut Research Station, Balaramapuram were used for the study. Ten seednuts collected from each palm were used for raising seedling progenies.

Of the seven mother palm characters studied Komadan palms were found superior in all characters except difference between the two types. The Komadan type further exhibited superior seedling vigour in terms of number of days taken for sprout, height, collar girth and mean number of split leaves. The results indicate that Komadan is a superior coconut ecotype deserving further research attention.

503. SILAS, E.G. 1989. National symposium on coconut breeding and management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988; recommendations. Kerala Agricultural University. 16 p. (KAU, Trichur 680 654, Kerala).

As a result of discussions held after papers were presented at the symposium, recommendations were drawn up for future direction of coconut breeding and management. This booklet contains those recommendations in the areas of (A) crop improvement, namely germplasm collection, conservation and evaluation (recommendations 1-4), heterosis breeding and hybrid seed production (5-14), breeding for pest, disease and environmental stress resistance (15-22), and biotechnology (23-25); (B) crop management, namely water management (26) nutrition (27-29), root wilt management and rehabilitation (30-32), and production statistics (33); and (C) processing technology, product development and marketing (34-40).

504. SINGH, SHIVADHAR; SINGH, VIJENDRA and SINGH, SHYAM. 1990. Heterosis in relation to growth and nutrient uptake in coconut seedlings. *Indian J. Plant Physiol* 33(1): 69-71. (CARI, Port Blair 744 101, A & N Islands).

Remarkable heterosis in D x T hybrid seedlings over female parent was observed for

seedling height, leaf area, dry matter production, uptake of nitrogen, phosphorus, iron and chlorophyll a and b. However, heterosis was not noticeable in nitrogen, phosphorus, and iron utilization efficiency.

505. SINGH, SHYAM; SHING, S. and SHRIDHAR, 1989. Evaluation of coconut cultivars for tender nut qualities under tide-prone marshy land. *J. Andaman Sci. Assoc.* 5(1): 39-42. (CARI, Port Blair, A & N Islands).

The quality of tender nuts of eight local cultivars grown under the tide-prone marshy land condition at the Central Agricultural Research Institute, Research Farm, Sipighat, A & N Islands was evaluated. Cultivar Port Blair Tall (medium red) was superior over others in respect of nut weight (2.4 kg) and volume of water (407.8 ml). As compared to the tall cultivars, dwarf yellow and dwarf orange maintained lower salt concentration (4.7 mmho/cm) in coconut water. Single nut weight and volume of water were reduced drastically in all three varieties while electric conductivity increased when coconuts were raised in a tide-prone marshy land.

506. SREELATHA, P.C. and KUMARAN, K. 1988. Seasonal variation in floral characters of T x CDO coconut hybrids. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers.* p.11. (College of Hort. KAU, Trichur, Kerala).

The floral characters of 69 WCT x CDO coconut hybrid palms maintained in the KADP farm of the Kerala Agricultural University, Vellanikkara were observed continuously for a period of one year from 15th Octoer, 1985.

507. SUKUMARAN, C.K. 1982. Assessment of specific and general combining abilities of nine coconut cultivars. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 12-15, 1982. Proceedings of PLACROSYM V.*

Edited by K.V.A. Bavappa and others. p.131-137. (CPCRI, Kasaragod, Kerala).

A diallel programme with 36 crosses and nine parents was undertaken to analyse the general and specific combining abilities (gca and sca) of nine coconut cultivars of diverse origin, and their hybrids, for five important characters. Results of diallel analysis showed that girth, height, total leaf production and leaf production during the year, were significant among the characters studied. The cross combinations, Laccadive Ordinary x Jamaica, and Fiji x Jamaica exhibited high sca effects for total leaf production and leaf production during the year. Laccadive, Jamaica, Java, Fiji and San Ramon cultivars proved useful as parents among the Tall cultivars. The D x T and T x D crosses involving Gangabondam as the dwarf parent flowered early. The total leaf production was also high in these crosses. In T x T crosses, Java x SS Green, Laccadive Ordinary x Jamaica, and Fiji x Jamaica flowered early.

508. SUKUMARAN, C.K., NARASIMHAYYA, G. and VIJAYA KUMAR, G. 1982. Path coefficient analysis in West Coast Tall coconut. *In: Symposium on Plantation Crops, 4th, CFTRI, Mysore, Dec. 3-5, 1981. Proceedings of PLACROSYM IV.* Edited by S. Vishveshwara and others. p.191-199. (CPCRI, Kasaragod, Kerala).

Yield in coconut is a complex character dependent upon a large number of components and their interactions. Path coefficient analysis was carried out to know direct and indirect effects of characters influencing yield. The correlation coefficients were partitioned into direct effects (path coefficients) and indirect effects in order to pinpoint the direct and indirect effects of these associations.

The analysis for yield of nuts during stabilized period showed that the major contributing characters which influenced di-

rectly or indirectly were average number of female flowers, number of functioning leaves at 19 years, and internodal distance at fixed mark. These characters influenced yield negatively indicating their value in selection.

509. **SUKUMARN NAIR, S. and BALAKRISHNAN, P.C.** 1988. Inbreeding depression in coconut (*Cocos nucifera* L.) *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.6. (RARS, KAU, Pilicode, Kerala).*

With the objective of finding out whether inbreeding depression exists in coconut, breeding programmes were taken up as early as 1924 to evolve inbred line and also to find whether hybrid vigour is met with within the crosses between such progenies. Eighteen West Coast Tall palms of the Coconut Research Station, Kasaragod were selfed in the years 1924 to 1926. The first and second generation progenies were planted at Pilicode during 1926 and 1961 respectively.

The studies made on the first and second generation selfed progenies revealed that selfed progenies were inferior to their grand parents and sibs. Hybrid vigour was met with when crossing was done between the progenies of same parent and it clearly indicated inbreeding depression in coconut by selfing.

510. **THANKAMMAPILLAI, P.K.; VIJAYAKUMAR, G. and RAVINDRAN, P.N.** 1983. Cytology of coconut. *In: Coconut research and development, proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976. Edited by N.M. Nayar, New Delhi: Wiley Eastern. p.62-70. (CPCRI, Kasaragod, Kerala).*

The chromosome number in coconut is  $2n = 32$ . Karyomorphological studies show slight differences between Tall and Dwarf varieties. Meiosis was generally regular in Tall cultivars and in hybrids between Tall and Dwarf, while several irregularities have been reported

in the Dwarf and semitall cultivars. Pollen fertility is very high in Talls and hybrids as compared to that in Dwarfs and semi-talls. Meiotic irregularities are commonly met within the 'spicata' palms and these are believed to have originated from Talls.

Free nuclear division has been reported in coconut milk. C-mitosis leading to high ploidy, several chromosome abnormalities occur in developing endosperm. In Philippines 'makapuno' nuts, the endosperm development is very abnormal. An inverse relationship between ploidy level and oil content has been also observed by some authors.

511. **THOMAS, K.M.** 1983. Some observations on the recovery of hybrid seedlings from Dwarf x Tall cross fertilized seed coconuts. *In: Coconut research and development, proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976. Edited by N.M. Nayar. New Delhi: Wiley Eastern. p.85-89. (Coconut Hybridization Scheme, Dept. of Agric. Trichur, Kerala).*

Percentage germination and recovery of hybrid seedlings were observed in a seedling population raised from 6123 coconut seeds obtained from 500 Dwarf Orange palms after hand pollination with pollen from selected Tall palms. The percentage of germination (84.0 - 88.9%) was much higher than those obtained by earlier workers and was comparable with the germination percentage of West Coast Tall Coconuts. The percentage of mortality of sprouts observed (2.4 - 4.4%) was also much lower than that reported by earlier workers. The hybrid seedlings identified on the basis of petiole colour six months after germination amounted to 62.4 - 74.1%. This was far higher than that reported earlier. The variance tests of homogeneity of proportion of hybrid seedlings between mother palms and between crosses where hybridizations were carried out showed that there were real differences between mother

palms and between crosses in the proportion of hybrid seedlings obtained. This may make it possible to identify palms which produce greater percentage of hybrids.

512. VALSALA, P.A. and KANNAN, K. 1988. Variability in open pollinated seedling progenies of Tall x Dwarf coconut hybrids. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.13-14. (College of Hort., KAU, Trichur 680 654, Kerala).*

The extent of variability in the seedling progenies obtained from the open pollinated seednuts of 30 T x D palms belonging to six grand parents was assessed. Significant differences were noticed in the number of days taken for germination of nuts and seedling vigour between the hybrids and also between the seedlings of the same hybrid. Some of the high yielding hybrid palms have produced less number of vigorous seedlings while some poor yielding palms have produced more number of vigorous seedlings showing thereby that the high yielding hybrids need not necessarily transmit their high yielding characters to their progenies under open pollination. Collection of seed nut from hybrids for further propagation should therefore be resorted to with care.

513. VALSALA, P.A. and KANNAN, K. 1990. Influence of seed nut characters on seedling vigour. *Indian Cocon. J.* 21(4): 11-13 (College of Hort., KAU, Trichur 680 654, Kerala).

The study was undertaken to assess the influence of seednut characters and days taken for germination on the seedling characters. A total of 1412 seednuts collected from 30 palms for the period 1979 Jan-May were the materials

for study. The results revealed that the seednut characters polar circumference, equatorial circumference, weight and volume were positively correlated with collar girth at 12 month stage. The days taken for germination was negatively correlated with collar girth. The collar girth showed high positive correlation with height and seedling vigour. So the study emphasised that for ensuring high yield seednut selection in terms of weight, volume and seedling selection in terms of early germination, higher collar girth is important.

514. VIJAYAKUMAR, G. and SATYABALAN, K. 1982. Yield and nut characteristics of open pollinated progeny of West Coast Tall and its hybrids with Chowghat Dwarf Orange and Gangbondam. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 12-15, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.172-176. (CPCRI, Kasaragod, Kerala).*

A comparative study was made of the performance of open-pollinated progeny of West Coast Tall (WCT), and its hybrids with Chowghat Dwarf Orange (CDO) and Gangabondam (GB) planted in laterite soil and maintained under rainfed conditions with the usual recommended dose of fertilizers.

The superiority of the hybrids over WCT, and among the hybrids, the superiority of CDO x WCT over the reciprocal hybrids WCT x CDO and WCT x GB in yield of nuts, copra and oil out-turn was observed. The study has also shown that CDO x WCT hybrids will be more suitable and will have to be preferred to the other two hybrids and the local WCT to increase coconut production under the laterite soil conditions in the country.

## 6. HORTICULTURE AND BIOTECHNOLOGY

✓ 515. BAJAJ, Y.P.S. 1984. Induction of growth in frozen embryos of coconut and ovules of citrus. *Curr. Sci.* 53(22): 1215-1216. (Tissue Culture Lab., PAU, Ludhiana, Punjab).

Construction of germplasm of short lived coconut seeds by cryopreservation method is reported. The immature embryos (1-1.5 cm) of West Coast Tall cultivar of coconut removed from nuts and stored for one month were partially dehydrated and were cut into transverse halves and treated, with a cryoprotectant solution (7% dimethyl-sulforide and 7% sucrose in Murashige and Skoogs' liquid medium) in Murashige and blotted dry, then wrapped in a single layer of sterile aluminium foil and frozen by gradually lowering into the liquid nitrogen cylinder, or were suddenly dropped in it and kept for 5 minutes. The frozen material was then thawed in water (35-40°C), washed and cultured on MS+2, 4-D (0.2 mg/l) + NAA (0.5 mg/l) + Kinetin (0.1 mg/l). The embryo showed a lag period upto 4 months without any growth. However, in some of the cultures, the embryos subsequently showed an overall swelling and elongation.

516. BHALLA-SARIN, N.; BAGGA, SUMAN; SOPORY, S.K. and MUKHERJEE, S. GUHA. 1986. Induction and differentiation of callus from embryos of *Cocos nucifera* L. by IAA-conjugates. *Pl. Cell Rep.* 5(5): 322-324. (School of Life Sciences, JNU, New Delhi).

Embryos from West Coast Tall nuts formed callus on Gamborg's B5 media containing IAA-conjugates (IAA-aspartic acid and IAA-alanine) at 2 mg/litre. Callus formation was greater when both conjugates were supplied (50%), than when they were supplied separately (40% for IAA-ala and 20% for IAA-asp). No callusing occurred with IAA or the amino acids when they were supplied alone or together. Shoot

and root differentiation was achieved by transferring calli to B5 medium supplemented with either IAA-asp (2.0 mg/l)+Kn (2.0 mg/l) or NAA (92.0 mg/l). Complete plantlets were obtained on B5 medium supplemented with NAA (90.5 mg/l) + BAP (2.0 mg/l) + PVP (1.0, g/l).

517. BHALLA-SARIN, N. and BAGGA, SUMAN. 1988. *In vitro* culture of embryos and other parts of *Cocos nucifera*. In: Seminar on Plant Tissue Culture, CPCRI, Kasaragod, Mar. 2-4, 1983. Proceedings of seminar. (School of Life Science, JNU, New Delhi).

Plantlets were raised *in vitro* from immature embryos of *Cocos nucifera* on Y3 medium supplemented with NAA 92 ppm) + Kn (2 ppm) and PVP (0.1%) or activated charcoal (1%). Callus could be initiated from these immature embryos on B5 medium supplemented with IAA amino acid conjugates and regenerated to form complete plantlets. Embryo like structures (embryoids) are formed from roots originating from callus as well as from sections of an embryo. Callus initiated from leaves, leaf bases and apical meristems could not be subcultured or regenerated.

518. D'SOUZA, L.; PAILY, J. and AROKIADOSS, V. 1988. Coconut embryo and tissue culture potentialities, problems and applications. In: National Seminar on Plant Tissue Culture, CPCRI, Kasaragod, Mar. 2-4, 1983. Proceedings of seminar. p. 140-145. (St. Aloysius College, Mangalore, Karnataka).

Tissues of adult coconut palms have been found to be very recalcitrant. Culture of embryo and seedling tissues gave encouraging results. The physiology of germination and growth of the embryo *in vitro* was studied. Multiple shoot formation, callus and organogenesis from the callus were obtained. The seedling tissues produced callus and embryoids. These results

could be used to optimise media for clonal propagation of adult trees.

519. GUPTA, P.K.; KENDURKAR, S.V.; KULKARNI, V.M.; SHIRGURKAR, M.V. and MASCARENHAS, A.F. 1984. Somatic embryogenesis and plants from zygotic embryos of coconut (*Cocos nucifera* L.) *in vitro*. *Pl. Cell Rep.* 3(6): 222-225. (Biochemistry Division, National Chemical Laboratory, Poona 411 008, Maharashtra).

Complete plants were grown from zygotic embryos cultured on Y3 basal liquid medium supplemented with coconut milk, BA and NSS. Explants from stem, leaf and rachilla of mature coconut trees turned green and swelled with 2, 4-D, K, NAA, BA and activated charcoal. Subapical regions of the stem on Y3 basal medium supplemented with 2, 4-D ( $4.52 \times 10^{-2}$  M). Globular embryo-like structures were obtained when this callus was subcultured to auxinless medium. Root formation was obtained from leaf explants on Y3 basal medium containing citric acid, ascorbic acid and 2, 4-D ( $4.52 \times 10^{-2}$  M). Globular embryo-like structures when transferred to medium with 2, 4-D ( $2.3 \times 10^{-1}$  M). These nodules developed roots from the base of the nodular growth whereas from the upper portion shoots were observed on Y3 basal liquid medium.

520. IYER, R.D. 1980. Use of tissue culture in development of coconut and other oil seeds (Abstract). *In: Seminar on achievements of seventies and future challenges in the field of oil seeds and oils, 35th, Bombay, Feb. 16-17, 1980.* p.4. (CPCRI, Kasaragod, Kerala).

Application of plant tissue culture of perennial and annual oilseed crops are discussed.

521. IYER, R.D.; RAJU, C.R. and PRAKASH KUMAR, P. 1988. Palm tissue culture; potential, priorities and applications in coconut and oil palm. *In: National Seminar on Plant Tissue Culture, CPCRI, Kasaragod, Mar. 2-4, 1983.*

Proceedings of seminar. p.129-132. (CPCRI, Kasaragod, Kerala).

Floral primordia of immature rachilla explants obtained from the first or second spathe after the spindle produced shoot-like neoformations with scale leaves. Nodular calli were produced in 2-4 D containing medium. Limited success has been obtained in inducing somatic embryogenesis directly from tender seedling leaf tissue of both coconut and oil palm.

522. JAGADEESAN, M. and PADMANABHAN, D. 1982. Induction of rooting in cotyledon callus of coconut. *Curr. Sci.* 51(11):567. (MKU, Madurai, T.N.).

Explants from cotyledons of 30-day-old coconut seedlings were cultured on Murashige and Skoog (MS), Schenk and Hildebrandt (SH) or Y3 (see HcA 46, 9779) basal medium supplemented with 0.5 mg/l NAA and 1 mg/l BA. Explants on MS and SH media ceased to grow whereas those on Y3 enlarged 5 to 7 fold within 4 weeks. When the explants were transferred to Y3 + 1 mg/aNAA some 7-10 rootlets appeared when the cultures were 60-70 days old. The development of roots is described and illustrated.

523. KALAMANI, A. and RANGASAMY, S.R. 1990. *In vitro* culturing of coconut embryo. *Indian Cocon. J.* 20(11): 9-10. (Biotechnology Unit, School of Genetics, TNAU, T.N.).

Embryos from mature nuts of the *Cocos nucifera* hybrid Tall x Gangabondam were cultured on 4 media. Y3 mineral medium was the best for embryo growth and development. Leaf initiation was best on Y3 medium supplemented with 1 mg kinetin per litre while rooting was induced by adding 1.5 mg NAA/l and 0% charcoal to the medium.

524. NAIR, M.K. 1989. Current state of the art on use of tissue culture techniques as

vegetative propagation of coconut in India. In Coconut Technology Meeting 26th, Bangkok, Thailand. May 15-19, 1989. Proceedings of the meeting. p.279-281. (CPCRI, Kasaragod, Kerala).

Explants from seedling leaf tissues gave rise to formation of callus and rhizogenesis growth to direct somatic embryogenesis. The filamentous type of calli, however, failed to develop on subculturing while the nodular callus could be subcultured. Zygotic embryos collected from tender nuts produced callus and also germinated to form plants. Methodology for production of plant from Zygotic embryos and subsequent transfer to field have been standardized.

525. NINAN, C.A.; MOHAN KUMAR. and JACOB, THOMAS. 1983. Tissue culture studies in coconut, cashew and cassava. In: International Congress of Genetics, 15th, New Delhi, Dec. 12-21, 1983. Abstracts of papers. p.140. (Dept. of Botany, Univ. of Kerala, Trivandrum, Kerala).

Induction of calli using different explants of coconut (*Cocos nucifera*), tapioca (*Manihot utilissima*) and cashew (*Anacardium occidentale*) has been tried. In coconut, tender leaves and leaf bases were found to callus maximum in a modified MS medium (Murashige and Skoog, 1962). Whole plants were regenerated from the apical meristems as well as from undifferentiated calli induced from nodal and petiole segments in tapioca. Maximum response in either case was obtained in a modified MS medium. In cashew, friable calli could be induced free of phenolic contents in SH (Schenk & Hildebrandt, 1972) medium with gibberellic acid.

526. PADMANABHAN, D. 1988. Potentials of embryo culture in *Cocos nucifera*. In National Seminar on Plant Tissue Culture, CPCRI, Kasaragod, Mar. 2-4, 1983. Proceedings of the

seminar. p.146-148. (Dept. of Plant Morphology, MKU, Madurai, T.N.).

Coconut embryo culture offers vast scope for basic and application oriented research. The applied aspects relate to topics such as cultivation of hybrid embryos to maturity, easy transportation to far-off places of genotypes in sterile culture and in cloning of hybrids from embryonal callus. One the basic front, coconut embryo culture can serve as an important tool in experiments of nutritional physiology and control of morphogenesis and differentiation. Cultivation of haustorial tissue as fatty substrates may open up a new area of food production by tissue culture.

527. PRAKASH KUMAR, P.; RAJU, C.R.; MINI CHANDRAMOHAN and IYER, R.D. Induction and maintenance of friable callus from the cellular endosperm of *Cocos nucifera* L. *Pl.Sci.* 40(3): 203-207. (CPCRI, Kasaragod, Kerala).

Fast-growing friable callus was initiated and maintained by subculture P, from West Coast Tall, from the part of the endosperm initially in contact with the embryo Eeuwens' Y3 mineral formulation with 2 mg kinetin/l, 50 mg 2, 4-D/l and 1 g activated charcoal/l was used to initiate callus in the dark. Callus was subcultured on basal medium containing reduced 2, 4-D and no charcoal. Success is partly attributed to the use of explants excised in sterile condition, with the embryo in situ, and to the high concentration of auxin the medium. Preliminary cytological studies indicated a high degree of aneuploidy (41 to 175 chromosomes) in callus cells.

528. RAJU, C.R.; PRAKASH KUMAR, P.; MINI CHANDRAMOHAN. and IYER, R.D. 1982. Attempts at tissue culture propagation of the coconut palm (*Cocos nucifera* L). In: National Seminar on Plant Propagation, Calcutta, Dec. 27-29, 1982. Abstracts of papers. p.100-101. (CPCRI, Kasaragod, Kerala).

The responses of seedling leaf tissue explants on basal medium supplemented with various combination of auxins and cytokinins in vitro are reported.

529. RAJU, C.R.; PRAKASH KUMAR, P.; MINI CHANDRAMOHAN and IYER, R.D. 1984. Coconut plantlets from leaf tissue cultures. *J. Plantn Crops* 12(1): 75-78. (CPCRI, Kasaragod, Kerala).

Coconut plantlets have been successfully produced for the first time directly from tender leaf segments of West Coast Talls and T x D hybrid seedlings without going through the intermediate stage of callus formation.

Time required for the formation of plantlets have been brought down from 16 weeks to 3 weeks and the frequency of production have been increased upto 80 as compared to 48 embryoids from a single segment. (5 mm).

530. RAJU, C.R.; SHYLA, R.; SAJINI, K.K. and BAVAPPA, K.V.A. 1988. Attempts at the production of clonal coconut palms. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.23.* (CPCRI, Kasaragod, Kerala).

Clonal propagation of coconut has resumed great importance to fix specific genotypes and to produce uniform coconut population to boost the productivity. However, the progress in coconut tissue culture had been slow and success limited to production of a few plantlets in the laboratory scale. Direct somatic embryogenesis was observed in tender leaf explants and established in soil. The conditions for such development are very critical and the response is erratic.

In another attempt, floral primordia were found to develop into shoot like structures on a variety of media. They were formed mainly

by the elongation of the thalamus with the appendages of floral whorls attached at different distances. In a few cultures, however, true shooting structures were observed.

Callus could be produced successfully from a variety of explants leaf, leaf bases, stem portions, zygotic embryos and endosperm. The callus from leaf bases showed potential for regeneration. White embryonal structure which were independent from the rest of the explant tissue were found to develop. Although it is yet to realize plantlets from these structures, this appears to be a more promising method than the direct somatic embryogenesis from tender leaves and transformation of floral primordia into shoots.

531. SATHYAVATHI KRISHNANKUTTY; MANGALA KUMARI, C.K. and MATHEW, A.G. 1990. Microstructure of coconut haustorium. *J. Fd. Sci. Technol.* 27(5): 302-303. (RRL, Trivandrum, Kerala).

Studies on the microstructure of coconut haustorium revealed the outermost layer to be composed of small, compactly arranged parenchyma cells which contained colourless oil droplets followed by two to three layers of the spongy tissue containing both oil droplets and starch grains. Subsequent five to six layers were rich in starch grains, their size ranging from 1.5 - 2.0  $\mu$ .

532. SETHURAJ, M.R.; RAO, G.G. and ASOKAN, M.P. 1989. Prospects of biotechnology in plantation crops. *J. Plantn Crops* 16(Suppl.): 9-16. (RRII, Kottayam, Kerala).

Technique showing potential for breeding plantation crops are outlined. They include (1) micropropagation and cell selection/somatic embryogenesis in rubber to develop elite clonal plants with their own roots and to produce drought and cold tolerant forms, respectively. (2) micropropagation for rapid multiplication and improvement of yields in cardamom. (3)

rapid multiplication of coconut with emphasis on disease resistance. (4) rapid clonal propagation by meristem culture in cashew, especially for the production of pathogen tolerant material. (5) selection and regeneration of rust (*Hemileia vastatrix*) resistant coffee cell lines. (6) somatic embryogenesis or micropropagation of oil palm to develop higher yielding elite clonal progenies and (7) micropropagation or techniques exploiting somaclonal variation to obtain tea varieties with enhanced leaf quality.

533. SHANTAMALLAIAH; KRISHNAMANOVAR, I.; MAHANTHESH, R. and GOWDA, T.N. VENKATESH. 1982. Notes on the tender coconut cultivars in Karnataka. *In: Symposium on Plantation Crops, 4th, CFTRI, Mysore, Dec. 3-5, 1981. Proceedings of PLACROSYM IV.* Edited by S. Vishveshwara and others. p.343-345. (AICCAIP, Agric. Res. Station, UAS, Arsikere, Karnataka).

Features of two forms valued in the 'maidan' parts of Karnataka for their tendernut characteristics, and known locally as Chitta Gangapani and Udda Gangapani are described.

534. SHETTY, M.S. KURUVINA and IYER, R.D. 1980. Tissue culture studies on coconut palm for clonal propagation. *In: National Symposium on Plant Tissue Culture, Genetic Manipulation and Somatic Hybridisation of Plant Cells, Bombay, Feb. 27-29, 1980. Proceedings of the symposium.* p.184-191. (CPCRI, Kasaragod, Kerala).

*In vitro* studies in coconut and turmeric were undertaken with the main objectives of achieving rapid multiplication of elite genotypes.

535. SHETTY, M.S. KURUVINA and IYER, R.D. 1981. An evaluation of tissue culture techniques in coconut and turmeric. *In: Symposium on Plantation Crops, 4th, CFTRI, Mysore, Dec. 3-5, 1981. Proceedings of PLACROSYM*

IV. Edited by S. Vishveshwara and others. p.101-112. (CPCRI, Kasaragod, Kerala).

*In vitro* studies in coconut and turmeric were undertaken with the main objectives of achieving rapid multiplication of elite genotypes.

In coconut a stage in the development of flower primordia was standardized for their conversion into vegetative structures on Y3 medium supplemented with 2 mg/l Kinetin. Shoot like structures were produced on the rachilla explants excised from the spadices which were extracted from the axils of first (maly) to third open leaves on the crown. Rooting of these structures was not regular. Calli were induced from stem and petiole explants of one year old WCT seedlings on Y3 medium supplemented with 0.5 to 1.0 mg/l 2, 4-D. Culture of isolated embryos was done on MS medium supplemented with 200 mg/l kcl. Embryos took four months to attain the first open leaf stage. Rooting of the seedlings was not regular. Seedlings when grown on liquid medium supplemented with 1 mg/l IBA produced roots.

In turmeric, a tissue culture method for rapid multiplication of clone 15B was developed. On MS medium supplemented with 0.2 mg/l kinetin and 0.4 mg/l BAP, the rate of multiplication was of the order of eight plantlets from every bud cultured for two months, which works out to over two lakh plantlets per bud per year. For initiating callus cultures, buds were grown on the same medium supplemented with 2 mg/l IAA or 0.5 mg/l 2, 4-D in dark. These calli were soft and friable. When exposed to light, IAA induced calli underwent differentiation to produce several plantlets. These plantlets could be separated and grown further before they were transplanted to polybags. These plants are growing very vigorously in the glasshouse for the last 8 months.

## 7. INFORMATION SERVICE

536. **ASIAN AND PACIFIC COCONUT COMMUNITY, JAKARTA (INDONESIA).** 1982. Report of the 'COCOTECH' meeting. Jakarta, Indonesia.

Reports presented by various countries on coconut production, coconut processing and industries, marketing etc. are included with the relevant tables and graphs.

537. **BAVAPPA, K.V.A., ed.** 1986. Research at CPCRI. CPCRI, Kasaragod. 82 p.

A report on the research achievements at CPCRI from the early setup at 1916 upto 1986. The co-ordinated projects and collaborative programmes as well as the impact of research efforts and a summary on the outlook upto 2000 AD are given.

538. **BAVAPPA, K.V.A.; NAIR, M.K. and DAS, P.K.** 1983. About CPCRI. CPCRI, Kasaragod. 24p.

The objectives and research activities of CPCRI, with its established divisions and laboratories at various centres are given. The research accomplishments are explained with colour photographs and the research priorities in the 80's are listed.

539. **CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1979. Nematodes, fungi, insects and mites associated with coconut palm. Technical Bulletin no. 2. Kasaragod: CPCRI. 236p. (CPCRI, Kasaragod, Kerala).

This bulletin gives a complete list of all the nematodes, fungi and insects and mites affecting coconut palm. The list includes 78 species of nematodes, 173 of fungi and 830 of insects and mites. The compilation can serve the nematologists, mycologists and entomologists as a source of reference.

540. **CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1986. Central Plantation Crops Research Institute by K.V.A. Bavappa and others. 19 p.

A brochure on CPCRI explaining the objectives, programmes, priorities, organisational set up and operation. A brief account of the major achievements in the field of mixed farming, root(wilt) management, harvest and post harvest technology, advances in tissue culture etc. is presented with photographs.

541. **CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1988. Palms and cocoa abstracts 1(1&2) 1987. q. Compiled and edited by D. Kamalavijayan. 86 p.

244 abstracts are arranged in alphabetical sequence by name of author under seven heads; Oil palm, Cocoa and Coconut (4 ref.), Oil Palm and Cocoa (2 ref.) Arecanut (4 ref.), Coconut (135 ref.), Cocoa (53 ref.), and Oil Palm (106 ref.). An author index is also provided.

542. **CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1988. Palms and cocoa abstracts 1(3 & 4) 1987. q. Compiled and edited by D. Kamalavijayan. 60 p.

165 references with abstracts are arranged alphabetically under nine heads: Arecanut and Oil Palm (1 ref.); Cocoa and Coconut (2 ref.); Cocoa, Coconut and Oil Palm (3 ref.); Arecanut (5 ref.); Cocoa (48 ref.); Coconut (54 ref.) and Oil Palm (37 ref.). An author index is also provided at the end.

543. **CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1989. Palms and cocoa abstracts 2(1 & 2) 1988. q. Compiled and edited by D. Kamalavijayan. 99 p.

247 abstracts are arranged alphabetically

by author name under ten heads: Palms (7 ref.); Arecanut, Cocoa and Coconut (2 ref.); Arecanut and Coconut (1 ref.); Cocoa and Coconut (4 ref.); Cocoa and Oil Palm (2 ref.); Coconut and Oil Palm (4 ref.); Arecanut (4 ref.); Cocoa (58 ref.); Coconut (101 ref.) and Oil Palm (59 ref.). An author index is also appended.

**544. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD. 1990.** Palms and cocoa abstracts 2(3 & 4) 1989. Compiled and edited by D. Kamalavijayan. 94 p.

272 references with abstracts arranged alphabetically by author name under 12 heads: Palms (10 ref.); Arecanut, Cocoa and Coconut (2 ref.); Arecanut, Coconut and Oil Palm (1 ref.); Cocoa, Coconut and Oil Palm (2 ref.); Arecanut and Cocoa (1 ref.); Arecanut and Coconut (2 ref.); Cocoa and Coconut (3 ref.); Cocoa and Oil Palm (3 ref.); Arecanut (8 ref.); Cocoa (104 ref.); Coconut (108 ref.) and Oil Palm (37 ref.). An author index is also provided.

**545. DAS, P.K. 1984.** A researcher's experience on scientific information on coconut in India. *In: Workshop on Coconut Information Net Working CID/IDRC, Colombo, Sri Lanka, Nov. 21-25, 1983. Proceedings of workshop. p.1-10.* (CPCRI, Kasaragod, Kerala).

The demanding need for coconut research information in India is emphasised here. The flow of information among the organisations is hampered due to their limited availability in the published form. As such, it is suggested here to establish computerised database of information storage and retrieval at the CPCRI with the assistance of IDRC, Canada and to have a joint venture with Coconut Information Centre (CIC), Sri Lanka and CPCRI. The research inputs in production, protection and processing sectors in Philippines, Indonesia, India, Sri Lanka and Malaysia are outlined. In Philippines, processing technology is of the highest order,

while other countries emphasise on production and protection aspects. Countries like USA, UK, FRG, Netherlands, Sweden and Japan devote their research efforts on coconut technology based on consumers' interest, while France has a massive coconut improvement programme under IRHO at Ivory Coast.

**546. DIVAKARAN PILLAI, M. 1978.** Bibliography on root(wilt) disease of coconut (*Cocos nucifera* Linn). *Indian Cocon. J.* 9(10): 3-8. (CPCRI (RS), Kayangulam, Kerala).

134 entries are included with author and subject index.

**547. DIVAKARAN PILLAI, M. 1980.** Bibliography on certain diseases of coconut. (*Cocos nucifera* L.) *Indian Cocon. J.* 10(10): 4-9. (CPCRI (RS), Kayangulam, Kerala).

This bibliography covers 31 diseases with 158 entries contributed by 157 authors.

**548. DIVAKARAN, PILLAI, M. 1981.** Bibliography on coconut (*Cocos nucifera* L.); 1936-1979. Kasaragod: CPCRI. 349 p. (Mimeo.) (CPCRI (RS), Kayangulam, Kerala).

An attempt has been made to cover the literature in the range of 1936-1979, falling under research papers, reviews, articles, reports etc. References are listed subject-wise, against authors arranged alphabetically. Author and subject indices are given at the end of each group and also a cumulative author index appended. This bibliography consists of 5769 entries contributed by 2013 authors.

**549. DIVAKARAN PILLAI, M. 1981.** Bibliography on lethal yellowing of coconut. (*Cocos nucifera* L.) *Indian Cocon. J.* 11(10): 5-9. (CPCRI (RS), Kayangulam, Kerala).

This bibliography consists of 161 entries contributed by 88 authors. The arrangement is in alphabetical order and serially numbered. An author index is also appended.

550. DIVAKARAN PILLAI, M. 1982. Bibliography on leaf eating caterpillar (*Nephantis serinopa* Meyr.); a pest of coconut. *Indian Cocon. J.* 13(7): 12-17. (CPCRI (RS), Kayangulam, Kerala).

This bibliography has 65 entries contributed by 63 authors. The entries are arranged in alphabetical order of the author's name. An author index is also appended.

551. DIVAKARAN PILLAI, M. 1982. Bibliography of the nutritional aspects of coconut (*Cocos nucifera* L.) *Indian Cocon. J.* 13(5): 8-19. (CPCRI (RS), Kayangulam, Kerala).

This bibliography has 171 entries, contributed by 139 authors arranged alphabetically by names of authors.

552. DIVAKARAN PILLAI, M. 1982. Bibliography on rhinoceros beetle, (*Oryctes rhinoceros* L.) *Indian Cocon. J.* 13(1): 6-14. (CPCRI (RS), Kayangulam, Kerala).

The bibliography has 135 entries contributed by 76 authors. The entries are in alphabetical order and are serially numbered. An author index is also appended.

553. DIVAKARAN PILLAI, M. 1983. Rat: a menace to coconut; a bibliography. *Indian Cocon. J.* 14(4): 9-12. (CPCRI (RS), Kayangulam, Kerala).

This bibliography includes 58 entries on articles dealing with damage caused by rats to the coconut palm and methods of control. Entries are arranged in alphabetical order by author.

554. DIVAKARAN PILLAI, M. 1984. Bibliography on red palm weevil *Rhynchophorus ferrugineus* Fabr., a pest of coconut (*Cocos nucifera* Linn.) *Indian Cocon. J.* 14(10) 5-8. (CPCRI (RS), Kayangulam, Kerala).

The bibliography has 47 entries contributed by 31 authors. Entries have been arranged

in alphabetical order of the name of the author(s) and serially numbered. An author index is also appended.

555. DIVAKARAN PILLAI, M. 1985. Bibliography on the association of the nematodes *Rhadinaphelenchus cocophilus* and *Radopholus similis* with coconut (*Cocos nucifera* L.) *Indian Cocon. J.* 16(5): 12-23. (CPCRI (RS), Kayangulam, Kerala).

The bibliography has 171 entries contributed by 78 authors. The entries are arranged in alphabetical order. Author index is appended.

556. DIVAKARAN PILLAI, M. 1985. Inter and multiple cropping with coconuts; a bibliography. *Indian Cocon. J.* 15(11): 15-25. (CPCRI (RS), Kayangulam, Kerala).

The bibliography has 143 entries contributed by 136 authors. Entries are arranged in alphabetical order by names of the author and serially numbered. Author index is also provided.

557. DIVAKARAN PILLAI, M. 1990. Bibliography on cadang-cadang disease of coconut. (*Cocos nucifera* L.) *Indian Cocon. J.* 21(4): 3-6. (CPCRI (RS), Kayangulam, Kerala).

This bibliography has 106 entries contributed by 77 authors. Entries have been arranged alphabetically by authors and serially numbered. An author index is also appended.

558. DIVAKARAN PILLAI, M. 1990. Bibliography on root(wilt) disease of coconut (*Cocos nucifera* Linn.) *Indian Cocon. J.* 21(2): 23-24. (CPCRI (RS), Kayangulam, Kerala).

216 entries are included with author and subject index.

559. GOVINDANKUTTY, M.P. and KOSHY, P.K. 1979. Nematodes associated with the coconut palm (*Cocos nucifera* L.). In: Nematodes, fungi, insects and mites associated with the coconut.

*Technical Bulletin* no. 2. Kasaragod : CPCRI. p.1-50. (CPCRI (RS), Kayangulam, Kerala).

A detailed account on nematodes associated with coconut, their occurrence and the context of investigations are presented. Nematodes in relation to coconut diseases and records of nematodes in various countries are also presented in tabulated form, together with an extensive bibliography on these.

**560. JOSEPH, THOMAS. and RADHA, K. 1979.** Fungi associated with the coconut palm (*Cocos nucifera* L.). *In: Nematodes, fungi, insects and mites associated with the coconut. Technical Bulletin* no. 2. Kasaragod: CPCRI. p.53-91. (CPCRI (RS), Kayangulam, Kerala).

Coconut palm harbours fungi numbering over 170, affecting various parts of the palm. Fifty four diseases having fungal association have been listed in this compilation. Attempt has been made by the authors to enlist the fungi and fungal diseases hitherto recorded on coconut. The compilation is useful as a 'Literature Bank' for mycological investigations on coconut.

**561. JOSHI, Y. 1984.** Analysis of publications of Central Plantation Crops Research Institute. *Q. Bull. IAALD* 29(1): 5-10. (CPCRI, Kasaragod, Kerala).

Publications of the CPCRI were analysed to give an indication of the performance and functions of the institute. Publication lists from annual reports of the institute from 1969-79 were analysed to determine those journals in which these contributions were published. The contents of publications have appeared mostly in 'crop journals' rather than subject journals. Most articles and papers have been tabulated on coconut and arecanut amongst the crops and crop protection amongst the subjects. Eight Indian journals account for 52.04% of the publications.

**562. JOSHI, Y. 1985.** Rationalizing library acquisitions policy; a case study. *Q. Bull. IAALD* 30(1): 1-13. (CPCRI, Kasaragod, Kerala).

Citations taken from research papers sent to various journals by staff of CPCRI during 1983-84 were analysed. A total of 114 papers yielded 990 references. The analysis covered different forms of cited documents and cited journals and their frequencies. The citation data was matched with the library's journal subscription list. This matching showed that 40% of subscribed journal were not cited and 50% of cited journals were not subscribed to. Out of the 213 journals cited 6.6% earned 38% of the citations. It is suggested that the Library's acquisitions policy should take into account two criteria i.e. journal use as shown by citations and relative man power in different subjects.

**563. KAMALAVIJAYAN, D. 1982.** Towards a national information centre for plantation crops (NICPLAC). *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others.* p.76. (CPCRI, Kasaragod, Kerala).

There is great need for introduction of advanced technologies to facilitate the flow of and accessibility to information on plantation crops. This would help our scientists to make optimal use of world's information base. The current world trend is for the establishment of specialised international information centres for individual crops viz. coconut, sorghum and millets, cassava, grain legumes, livestock, etc. Such centres are available in India under DST, in food technology, leather, machine tools, etc. However, there is no such system to cater to the requirements of agricultural scientists in the country especially those working on plantation crops. The lack of proper co-ordination and organised efforts for providing better information services to R and D organizations, educational institutions and

governmental agencies interested in plantation crops research and industry is a major handicap for productive research and development. Establishment of a National Information Centre for Plantation Crops (NICPLAC) including rubber, coffee and tea, at the CPCRI will be able to: (1) Collect, collate and disseminate pertinent information on all areas of research; (2) serve as a clearing house for information of different aspects of these crops and collaborate with other similar information systems in the country; (3) and act as a feeder to similar national and international systems. The present library and documentation units at various plantation crops research centres in the country will function as feeder units for NICPLAC.

**564. KAMALAVIJAYAN, D., comp.** 1984. Union catalogue of periodical holdings. CPCRI, Kasaragod. 98p. (CPCRI, Kasaragod, Kerala).

The union catalogue covers the periodical holdings of CPCRI Libraries at Kasaragod, Kayangulam, Vittal and Calicut upto 1983 and divided into two parts. The main part consisting of 580 titles covering about 14,000 volumes with bibliographical details are arranged in alphabetical order. The other part covers the subject index, in which the journals are classified subjectwise and arranged alphabetically.

**565. KAMALAVIJAYAN, D.** 1991. Information services on plantation crops in India with special reference to palms and cocoa. 13p. Paper presented in the Seminar on Science and Technology Information Systems in India; Emerging Trends, RRL, Trivandrum, Jan. 17-19, 1991. (CPCRI, Kasaragod, Kerala).

A review of the state of art of the information services in the R and D institutions in the plantation crops sector is made. The conclusion is that the information services provided by these are mainly confined to the particular institution/development board only. There is no central information service as such

in the country except to a limited extent being provided by the research institution viz. CPCRI, NRCS, NRCC, RRII, etc. which are quite insufficient for meeting the requirements on a national scale. A detailed analysis of the various information service provided by CPCRI in Palms and Cocoa is outlined. Suggestion for organizing both technical and economic marketing information service in India is also made.

**566. KAMALAVIJAYAN, D. and THAMPAN, P.K.** 1984. Coconut information services in India. *ALIS Bull.* 8(1-2): 29-41. (CPCRI, Kasaragod, Kerala).

Deals with various agencies engaged in research, development, economics and marketing of coconut in the country. National agencies responsible for generation, collection, processing and dissemination of both technical and economic marketing information services are highlighted. The need for pooling the existing information resources in coconut available among the various coconut growing countries adopting latest technologies for information collection, processing, storage and retrieval, making it available to the end users is stressed.

**567. KURIAN, CHANDY; SATHIAMMA, B. and PILLAI, G.B.** 1979. World distribution of pests of coconut. Technical Document no. 119. FAO Plant Protection Committee for the South East Asia and Pacific Region. FAO Regional Office for Asia and Far East, Bangkok, Thailand. 53 p. (CPCRI (RS), Kayangulam, Kerala).

A list is presented of the important insects and mite pests in each of the coconut growing countries. A world map indicating the serial number of countries as listed is also included.

**568. KURIAN, CHANDY; SATHIAMMA, B.; PILLAI, G.B. and PONNAMMA, K.N.** 1979. Insects and mites associated with the coconut palm. (*Cocos nucifera* L.) In: Nematodes, fungi,

insects and mites associated with coconut palm. Technical bulletin no. 2. Kasaragod: CPCRI. p.93-236. (CPCRI (RS), Kayangulam, Kerala).

The coconut palm is subject to the infestation of a variety of insect pests and mites. In the present compilation authors have made every effort to update the check list on pests prepared earlier by various workers and to furnish the bibliography on coconut pests to the extent possible.

569. NAIR, M.K. and MENON, A.R.S. 1990. Coconut research institutes in India; Central Plantation Crops Research Institute. *Indian Cocon. J.* 21(2): 6-12. (CPCRI, Kasaragod, Kerala).

The paper introduces CPCRI as one of the major research Institutes of India dealing with research on coconuts. A brief history of the Institute is described followed by the mandate and approach. Some of the recent achievements of the Institute such as discovery

of hybrid vigour and increasing productivity, soil management and nutrition, water management, tree crops based cropping and farming systems, management of root(wilt) affected gardens etc. are described. Besides, other achievements in the control of diseases and pests, tissue culture work, harvest and post harvest technology are also briefly described.

570. NAIR, N.M. 1977. Sixty years of coconut research and development in India. *Curr. Sci.* 46(10): 330-331. (CPCRI, Kasaragod, Kerala).

A general description of the symposium held in India to celebrate 60 years of research in coconut in India; 320 Scientists and delegates from all over India and most of the coconut growing countries of the world attended; 80 papers in various field of research were presented during the symposium on the various fields of research being carried out all over the world.

## 8. MICROBIOLOGY

### 8.1 Bacteria and fungi

571. BOPAIAH, B.M. 1987. Beneficial microorganisms in the root region soils of coconut based mixed farming systems. In: Southern Regional Conference on Microbial Inoculants, 7th, UAS, Bangalore, Jun. 25-26, 1987. Abstracts of papers. p. 32. (CPCRI (RS), Vittal, Karnataka).

The beneficial microorganisms associated in the root region soils of coconut mixed farming and coconut monocropping systems were studied. Asymbiotic  $N_2$ -fixers and P-solubilizers were more in coconut and napier grass of mixed farming as compared to coconut sole cropping. The enumeration of nitrifying bacteria revealed slightly higher population of *Nitrosomonas* sp. in mixed farming system but the counts of *Nitrobacter* did not show any variation. The VA-mycorrhizal spore count and root colonisation (%) was studied for three depths (0-25, 26-50 and 51-100 cm). The nitrogen fixing and P-solubilizing ability were studied in vitro.

572. BOPAIAH, B.M. 1988. Microbiological studies in relation to high density multispecies cropping system in coconut. Ph.D. thesis. University of Mysore, Mysore. p.167. (CPCRI, Kasaragod, Kerala).

The influence of coconut based multi-storeyed cropping (coconut+pepper+cacao/cinnamon+pineapple) and coconut based mixed farming (coconut+pepper+ napier grass) on soil microflora (bacteria, fungi and actinomycetes), beneficial microorganisms ( $N_2$ -fixers, phosphatase solubilizers, nitrifying bacteria and VA-mycorrhizae), soil enzymes (urease, dehydrogenase and phosphatase), soil microbial biomass, cellulose decomposition and soil fertility (organic carbon, NPK) was investigated in comparison with coconut monocropping

system. In general the microflora and soil biological activities were greater in multistoreyed and mixed farming systems as compared to coconut monocropping. The occurrence and the activities of rhizosphere and rhizosphere microorganisms with particular reference to  $N_2$ -fixers (*Beijerinckia* and *Azospirillum*), P-solubilizers and the effect of certain pesticides on the growth of microorganisms (bacteria, fungi,  $N_2$ -fixers and P-solubilizers) *in vitro* was studied. The antagonistic studies on *Phytophthora arecae* and *P. palmivora* *in vitro* revealed some potential antagonistic fungi (*Trichoderma* spp., *Aspergillus* spp., *Penicillium* spp. and *Fusarium* sp.) and bacteria (*Bacillus* spp. and *Pseudomonas* sp.). Biochemical characterisation of root exudates of coconut and soils of different coconut based cropping systems were studied.

573. BOPAIAH, B.M. and SHETTY, H.S. 1990. Soil microflora and biological activities in the rhizospheres and root regions of coconut based multistoreyed cropping and arecanut monocropping systems. *Soil Biol. Biochem.* 23(1): 89-94. (CPCRI (RS), Vittal, Karnataka).

Microflora, enzyme activities, microbial biomass, C and N mineralization in the rhizosphere and root region soils of coconut-based multistoreyed cropping (pepper, cacao and pineapple) and arecanut monocropping systems were studied. The rhizospheres of the different crops had greater numbers of microflora than nonrhizosphere soils. There were fewer bacteria and fungi in the root region soils of coconut monocrop as compared to multistoreyed cropping system. The microflora, enzyme activities, C and N mineralization decreased with soil depth. Urease, dehydrogenase and phosphatase activities showed

variable trends in the root regions and rhizospheres of the different crops. The microbial biomass in the root region soil was highest in the coconut and cacao of the multistoreyed cropping system. The organic C, total N, P and K were higher in the root region soils of multistoreyed cropping system than in the coconut monocropping system.

574. BOPAI AH, B.M.; SHETTY, H.S. and NAGARAJA, K.V. 1987. Biochemical characterization of the root exudates of coconut palm. *Curr. Sci.* 56(16): 832-833. (CPCRI (RS), Vittal, Karnataka).

Root exudates contained  $993 \pm 174$   $\mu\text{g/g}$  total sugars and  $226 \pm 43$   $\mu\text{g/g}$  reducing sugars. The sugars detected were raffinose, lactose, glucose and fructose. The total amino acid content was  $18.6 \pm 3.9$   $\mu\text{g/g}$  and included serine, glycine, glutamine, alanine, phenylalanine, leucine and isoleucine. The exudates also contained  $11.6 \pm 3$   $\mu\text{g/g}$  phenol, and succinic acid.

575. GHAI, S.K. and THOMAS, GEORGE, V. 1986. And now a biofertilizer. *Intensive Agric.* 26(6): 15. (CPCRI, Kasaragod, Kerala).

Vesicular-arbuscular mycorrhizae popularly known as VA-mycorrhizae or VAM is now attracting attention as a new type of biofertilizer. Yield increases due to inoculation with VAM fungi have been reported in a number of crops particularly in marginal soils poor in phosphorus. Improved utilisation of insoluble phosphates like rock phosphate has also been reported due to VAM inoculation.

576. GHAI, S.K. and THOMAS, GEORGE, V. 1989. Occurrence of *Azospirillum* in coconut based farming systems. *Pl. Soil.* 114: 235-241. (CPCRI, Kasaragod, Kerala).

Occurrence of *Azospirillum* was investigated in coconut-based farming systems involving a total of 26 species of crops. The

extent of occurrence of *Azospirillum* seemed to depend upon the crop combinations. In a mixed farming system where guinea grass was one of the component crops, more root fragments of coconut and pepper demonstrated *Azospirillum* reduction activity than when guinea grass was absent. The large variation in the extent of association of *Azospirillum* in different crops indicated the need for inoculation with efficient cultures in a number of crops in coconut-based cropping systems.

577. MERILYN, V.J. 1989. Studies on dinitrogen fixation by *Beijerinckia* associated with rhizosphere of coconut. M.Phil. dissertation. Mangalore University, Mangalore. 84 p. (CPCRI, Kasaragod, Kerala).

The association of non-symbiotic nitrogen fixing bacteria, *Beijerinckia* in the rhizosphere soils of coconut under laterite and sandy soil types in the coconut growing tract of Kerala was investigated. Sandy soils had significantly more population of *Beijerinckia* than laterite soils. The different isolates of *Beijerinckia* showed nitrogenase activity in the range of 2.88 to 78.94  $\mu\text{M C}_2\text{H}_4$  tube<sup>-1</sup> h<sup>-1</sup> when tested by acetylene reduction method. The effect of cultural conditions (incubation time, pH, temperature), Carbon sources, combined nitrogen and fungicides on growth and N<sub>2</sub> fixation by *Beijerinckia* were studied under *in vitro* conditions. *Beijerinckia* inoculation was effective in increasing the growth of pepper and maximum response was observed when inoculation was done with low level of nitrogen application.

578. NAIR, P.K.U. 1980. Deterioration of copra by fungi (dry coconut). *Agric. Res. J. Kerala* 18(2): 200-203. (College of Agric., KAU, Trivandrum 695 022, Kerala).

Fungi *Aspergillus niger*, *Aspergillus* sp; *Penicillium* sp., *Rhizopus* sp., *Diplodia* sp. and *Trichoderma* sp. were isolated from copra

samples, which caused reduction in the oil content. Except *Rhizopus* sp. all the fungi grew well in Richard's solution containing coconut oil as carbon source. This is the first report of *Trichoderma* sp. on copra.

579. NAIR, R.R. 1984. Factors affecting the yield and quality of copra. In: Seminar on Coconut Processing and Utilization, RRL, Trivandrum, Feb. 8, 1984. Proceedings of seminar. p.72-84. (RRL, Trivandrum, Kerala).

Genetic and environmental factors influencing copra out turn and quality in WCT variety of coconut palms are discussed.

580. NAIR, S.K. and RAO, N.S. SUBBA. 1977. Distribution and activity of phosphate solubilising microorganisms in the rhizosphere of coconut and cacao under mixed cropping. *J. Plantn Crops* 5(2): 67-70. (Div. of Microbiology, IARI, New Delhi).

Two efficient phosphate solubilizing microorganisms, *Pseudomonas* sp. and *Aspergillus niger*, were isolated from the rhizosphere of coconut and cacao. They were capable of solubilizing 49.0% and 49.7% inorganic phosphate. The incidence of phosphate solubilizing microorganisms and available phosphorus in different rhizosphere soils were directly related.

581. NAIR, S.K. and RAO N.S. SUBBA. 1977. Microbiology of the root region of coconut and cacao under mixed cropping. *Pl. Soil.* 46(3): 511-520. (Div. of Microbiology, IARI, New Delhi).

Mixed cropping of cacao in coconut plantations improved the microbial activity in the rhizosphere of coconut which may be attributed to an increase in organic matter content of soil due to periodic shedding of cacao leaves. When compared to coconut cultivation without cacao, mixed cropping of coconut with cacao appeared to stimulate the

population of bacteria and fungi including the N fixing and phosphate solubilizing bacteria in the rhizosphere of coconut.

582. NAIR, S.K. and RAO N.S. SUBBA. 1978. Occurrence of fungi in the coconut rhizosphere and rhizoplane and interaction among them. *J. Plantn Crops* 6(2): 96-97. (Div. of Microbiology, IARI, New Delhi).

In this study the effect of *Trichoderma lignorum* on the growth of other fungi occurring in the coconut rhizosphere and rhizoplane was observed under *in vitro* conditions. It was shown that *T. lignorum* inhibited the growth of many fungi like *Fusarium* spp., *Gliochadium* sp., *Sepedonium* sp., *Cladosporium* sp., *Penicillium* sp. and *Rhizoctonia* sp. occurring in the coconut rhizosphere and rhizoplane. The growth of *Aspergillus niger*, *A. flavus*, and *A. fumigates* was not inhibited by *I. lignorum*.

583. PALANISWAMI, A.; THENAMMAI VALLIAPPAN, and NEELAKANTAN, S. 1989. Effect of fungal contamination of copra on the quality of coconut oil. *Indian Cocon. J.* 19(11): 1-4. (Dept. of Food Science and Nutrition, Agril. College and Res. Institute, TNAU, Madurai, 625 104, T.N.).

The incidence of fungi on copra ranged from 1.5 to 2 per cent. *R. nigricans*, *A. niger*, *A. clavus*, *Penicillium* sp. were the storage fungi recorded on copra besides *B. theobromae*.

The iodine value, saponification value, FFA and peroxide value showed an increase while the melting point and smoke point were lower in contaminated oils than in check.

Eventhough the aflatoxin was in traces with oil contaminating with *R. nigricans* and *N. theobromae*, the onset of rancidity was quicker, as compared to oil contaminated with *A. flavus* and check.

584. PAUL, P.G.; SAM RAJ, J. and PHILIP, SUSAMMA. 1980. Changes in the quantity

and quality of coconut oil due to microbial infection of copra. *Agric. Res. J. Kerala* **18**: 69-71. (College of Agric., KAU, Trivandrum 695 022, Kerala).

Studies on the quantitative and qualitative changes of coconut oil consequent to inoculation by different fungi and bacteria singly as well as in combination showed a progressive reduction in oil content and increased rancidity. Maximum reduction in oil content was recorded by *Aspergillus niger* and *Aspergillus flavus*.

**585. PHILIP, SUSAMMA.** 1980. Production of cellulolytic enzymes by the fungi associated with the spoilage of copra. *Madras. Agric. J.* **67**(9): 603-605. (Dept. Plant. Pathology, Coconut, Res. Station, Kumarakom, Kottayam, Kerala).

The formation of C<sub>1</sub> and C<sub>x</sub> celluloses by fungi known to be associated with the spoilage of copra was studied in nutrient medium and on copra. *Botryodiplodia theobromae*, *Aspergillus flavus* and *A. niger* produced more C<sub>1</sub> cellulose and *Curvularia senegalensis* and *Penicillium citrinum* produced more C<sub>x</sub> enzyme in the nutrient medium. Very little enzyme activity was observed on copra.

**586. PHILIP, SUSAMMA.; KRISHNAN NAIR, M. and MENON, M.R.** 1985. Bioassay of aflatoxins produced by *Aspergillus flavus* Link Ex Fries in copra. *Indian Cocon. J.* **15**(11): 10-12. (College of Agric., KAU, Trivandrum, 695 022, Kerala).

*Aspergillus flavus* Link Ex Fries commonly associated with the deterioration of copra, was found to liberate aflatoxin B<sub>1</sub> in appreciable quantities. The biological effects of aflatoxin were studied by feeding 1 g of infected copra to ducklings for a period of 30 days. A very high mortality was observed. Surviving birds showed degeneration of hepatic cells and kidney cells and proliferation of bile duct.

**587. PHILIP, SUSAMMA and MENON, M.R.**

1983. Aflatoxin B<sub>1</sub> in copra. *Indian Cocon. J.* **14**: 1-3. (College of Agric., KAU, Trivandrum, Kerala).

Samples of copra collected from different parts of Trivandrum district were analysed for the presence of aflatoxin B<sub>1</sub> for a continuous period of one year and results presented.

**588. PHILIP, SUSAMMA; MENON, M.R. and ABRAHAM, ALICE.** 1980. Moisture content and succession of microflora in copra. *J. Plantn Crops* **8**: 56-57. (College of Agric., KAU, Trivandrum 695 022, Kerala).

A clear succession of fungal population was observed. A moisture content of about 20 per cent was favourable for the growth of Mucorales while a moisture of 17-18 per cent was highly suited for the luxuriant growth of various *Aspergillus* species. *Botryodiplodia theobromae* and *Curvularia senegalensis* preferred a range of 8-10 per cent and *Penicillium citrinum* dominated at lower limit viz., 5-7 per cent.

**589. PHILIP, SUSAMMA; MENON, M.R. and ABRAHAM, ALICE.** 1981. Quantitative changes in the aminoacids of copra due to fungal infection. *J. Fd. Sci. Technol.* **18**(6): 254-255. (College of Agric., KAU, Trivandrum, Kerala).

The aminoacid pattern of copra was found to be altered due to infection by fungi. Copra infected by *Botryodiplodia theobromae* did not show much variation as compared to the control, while samples infected by *Mucor liemalis* and *Curvularia senegalensis* indicated lower and *Rhizopus oryzae* infected samples showed higher aminoacid content.

**590. PHILIP, SUSAMMA; MENON, M.R. and THOMAS, E.J.** 1980. Influence of moisture and weather conditions on microbial population in copra. *J. Plantn Crops* **8**(1): 36-39. (College of Agric., KAU, Trivandrum, Kerala).

Copra samples collected at monthly intervals for one year from 4 coconut oil mills

in Trivandrum (Kerala) showed that development of fungal and bacterial populations was influenced by moisture content of copra, relative humidity, temperature and rainfall.

591. POTTY, V.P.; GEORGE, MATHEW. and JAYASANKAR, N.P. 1977. Effect of crop mixing on the coconut rhizosphere. *Indian Cocon. J.* 8: 1-2 (CPCRI (RS), Kayangulam, Kerala).

The cultivation of fodder grass, hybrid napier in root (wilt) affected coconut gardens resulted in favourable alteration in the soil microflora (bacteria, fungi, N<sub>2</sub>-fixers and P. solubilizers) and the micro organisms colonising on the root surface of coconut.

592. POTTY, V.P. and JAYASANKAR, N.P. 1983. Influence of crop mixing of hybrid napier on root zone microflora of coconut palm. *In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976.* Edited by N.M. Nayar. New Delhi: Wiley Eastern. p.300-303. (CPCRI (RS), Kayangulam, Kerala).

Intercropping of fodder hybrid napier with coconut palms resulted in the proliferation of total bacteria and nitrogen fixing organisms in the coconut rhizosphere, irrespective of the condition of the palm. Compared to the palms in the control plot, crop mixing enhanced phosphate solubilizing bacteria in root region of root(wilt) affected coconut palms harbouring significantly higher numbers. The trend was however reversed after the application of inorganic manures. There was decrease in the nitrogen fixing and phosphate solubilizing microflora in the soil adhering to the coconut roots. The difference between the experimental and control plot was also not significant.

593. POTTY, V.P.; JOSEPH, K.V.; GEORGE, MATHEW and JAYASANKAR, N.P. 1980. Microbial degradation of coconut waste materials. *In: Symposium on Plantation Crops, 2nd, Ootacamund, Jun. 26-29, 1979.* Pro-

ceedings of PLACROSYM II. Edited by C.S. Venkataram and others. p.93-98. (CPCRI (RS), Kayangulam, Kerala).

Retting of coconut husk yields coir fibre and coconut pith both of which are resistant to microbial attack. The former finds a place in commerce, while the disposal of the latter is a problem. Enrichment culture methodology using lignocellulose as source of carbon yielded a fungus identified as *Poria ravanulae*. The fungus could utilise coconut pith which is essentially a ligno-cellulose complex, as source of carbon for its growth. The coconut *P. ravanulae* isolates were lignoclastic, its polyphenol oxidase was noninducible and could use a range of phenolic substrates for growth. Replacement culture techniques indicated the conversion of trihydric phloroglucinol to dihydric resorcinol.

594. ROHINI IYER. 1981. Rhizosphere microflora in crop mixed coconut soil. *Philipp. J. Cocon. Studies*: 6(2): 42-45. (CPCRI, Kasaragod, Kerala).

A study on the rhizosphere microflora of coconut intercropped with perennial spice crops viz., cinnamon, nutmeg and clove has shown that there is qualitative and quantitative shift in the fungal and bacterial flora of the intercropped coconut when compared to that of monoculture. Rhizosphere of the coconut becomes obviously richer quantitatively and qualitatively in fungal flora when intercropped with tree spices indicating a trend of positive complimentation. In the case of the bacterial population, though there has been a decrease in the total population the fraction of nitrogen fixers and phosphate solubilizers recorded increase. This may be due to the disturbance caused by the introduction of new crops into the coconut garden and it would be worthwhile to study the system periodically to know the trend of population shift till it reaches equilibrium.

595. THOMAS, GEORGE V. and GHAI, S.K. 1987. Now bionitrogen for coconut too. *Intensive Agric.* 25(10): 26-27. (CPCRI, Kasaragod, Kerala).

There is a lot of potential for exploiting the nitrogen fixing ability of micro-organisms for increasing the supply of nitrogen to coconut. Green manure and cover legumes having association with efficient Rhizobium strains can contribute substantial quantities of nitrogen when grown in basins or interspaces. The associative nitrogen fixing bacteria, *Azospirillum* and asymbiotic N<sub>2</sub>-fixer, *Beijerinckia* are associated with coconut roots and rhizosphere soils, respectively.

596. THOMAS, GEORGE, V. and GHAI, S.K. 1991. Influence of rhizobium inoculation and seed pelleting on nodulation of green manure legumes in an acidic coconut soil. *J. Plantn Crops* 18(Suppl.): 72-77. (CPCRI, Kasaragod Kerala).

The effect of rhizobial inoculation and seed pelleting was studied in an acidic soil on nodulation, N<sub>2</sub> fixation and growth of green manure legumes which were found to be suitable for cultivation in coconut gardens. Three *Rhizobium* strains (32 HI, EOI and PAU Cowpea) were used as inoculants for *Calopogonium mucunoides* and an IARI strain (L1) and a local isolate (L2) for *Leucaena leucocephala*. The effectiveness of pelleting materials such as rock phosphate, Ca CO<sub>3</sub>, charcoal and dolomite was compared along with different inoculants. Rhizobium inoculation resulted in increased growth and nodulation in both legumes and the extent of response varied when different cultures were used. The response in nodulation behaviour, dry matter yield and nitrogen concentration in tissues was significantly more only when pelleting was done on *Rhizobium* inoculated seeds. The difference in response due to the use of different pelleting materials was not significant. The present study indicated

the need for pelleting along with rhizobial inoculation to get substantial improvement in nodulation and nitrogen fixation of green manure legumes in acidic coconut soils.

597. THOMAS, GEORGE, V. and SHANTARAM, M.V. 1984. Grow leguminous green manure crop in coconut basins. *Indian Fmg* 34(6): 5-6. (CPCRI, Kasaragod, Kerala).

These studies indicated the possibility of cultivating/growing *Pueraria phaseoloides*, *Mimosa invisa* and *Calopogonium mucunoides* as ideal green manure crops and the application of green manure resulted in significant increase in the soil biological and biochemical activities in the root region of coconut.

598. THOMAS, GEORGE, V. and SHANTARAM, M.V. 1984. *In situ* cultivation and incorporation of green manure legumes in coconut basins an approach to improve soil fertility and microbial activity. *Pl. Soil* 80(3): 373-380. (CPCRI (RS), Kayangulam, Kerala).

Nine species of green manure legumes were tested for the ability to grow and establish in basins under coconut in Kerala, *Pueraria phaseoloides*, *Mimosa invisa* and *Calopogonium mucunoides* were most suitable. These three species were effectively nodulated with native soil rhizobium. Green manuring at 20 kg per palm generally increased microbial populations and enzyme activities in the coconut rhizosphere.

599. THOMAS, GEORGE V. and SHANTARAM, M.V. 1986. Evaluation of green manure legumes on coconut basins and their influence on biological activity and fertility in soil. *In: Workshop on Beneficial Microbes in Tree Crops Management, CPCRI, Kasaragod, Sep. 8-9, 1986.* Extended summaries of papers. p.8. (CPCRI, Kasaragod, Kerala).

*Pueraria phaseoloides*, *Calopogonium mucunoides* and *Mimosa invisa* contribute 15-

30 kg of green matter per basin, which is equivalent to one-third of nitrogen requirement of the palm. The microflora and dehydrogenase activity in the rhizosphere were significantly increased during the vegetative stage and at 30 days after its incorporation but the urease activity did not show any increase or decrease. Mineralization of carbon and the total nitrogen content also increased in soils of green manured basin at 30 days of incorporation as compared to control.

600. THOMAS, GEORGE, V. and SHANTARAM, M.V. 1986. Solubilization of inorganic phosphates by bacteria from coconut soils. *J. Plantn Crops* 14(1): 42-48 (CPCRI, Kasaragod, Kerala).

Studies on the distribution of phosphate-solubilizing bacteria in coconut plantation soils revealed that clayey soils harboured less population than laterite, alluvial and sandy soils. *Pseudomonas* sp., *Micrococcus* sp., *Micrococcus roseus*, *Bacillus subtilis*, *Corynebacterium* sp. and *Alcaligenes* sp. were the phosphate-solubilizing bacteria encountered in coconut soils. *In vitro* estimation of the phosphate-solubilizing ability of the isolates revealed solubilization of 19.5 to 54% of the insoluble phosphates supplied in the culture broth. Inoculation of soils with efficient phosphate-solubilizing bacteria after addition of farm yard manure and rock phosphate released more available P from insoluble P sources. *M.roseus* and *B.subtilis* possessed better capacity to survive in unamended soils, as compared to the other phosphate-solubilizing bacteria tested and have a great potential as inoculants in crop plants for better utilization of insoluble P sources.

601. THOMAS, GEORGE V. and SHANTARAM, M.V. 1987. Isolation and testing of symbiotic effectiveness of Rhizobia for *Pueraria phaseoloides* and *Calopogonium mucunoides*. *Mysore J. Agric. Sci.* 21: 450-454. (CPCRI, Kasaragod, Kerala).

Isolates of *Rhizobium* sp. obtained from eight different forage legumes were tested for their effectiveness and nitrogen fixing efficiency on *Pueraria phaseoloides* and *Calopogonium mucunoides* in Leonard jar assemblies. Both the legumes were promising in their rhizobial requirement. Two efficient isolates were recognised which were further tested for their efficiency under field conditions along with two composite cultures from NIFTAL. The NIFTAL cultures were effective in nodulating and increasing the dry matter production in *C.mucunoides*. *P.phaseoloides* was effectively nodulated by native soil rhizobia and hence did not respond to rhizobial inoculation.

602. THOMAS, GEORGE, V.; SHANTARAM, M.V. and HEGDE, S.V. 1985. Response to rhizobial inoculation in *Leucaena leucocephala* (Lam.) de wit. *Indian J. Microbiol.* 25(1&2): 103-104. (CPCRI, Kasaragod, Kerala).

The response to *Rhizobium* inoculation was studied in two cultivars of *Leucaena leucocephala*, K-67 and K-4 using a local isolate and a culture obtained from UAS, Bangalore. Significant increase in dry weight and nitrogen yield to the extent of 50% over control was recorded in K-67 cultivar when inoculated with the UAS culture. The biomass and N<sub>2</sub> yield did not vary significantly in K-4 cultivar due to inoculation with the two *Rhizobium* cultures whereas the nodule number and biomass increased significantly in response to inoculation with the local isolate. The response to *Rhizobium* inoculation was better in K-67 cultivar when compared to that in K-4.

603. THOMAS, GEORGE, V.; SHANTARAM, M.V. and JAYASANKAR, N.P. 1987. Microbiology of coconut (*Cocos nucifera* Linn.) in relation to cultivation, processing, product diversification and biodeterioration. *J. Plantn Crops* 15(2): 72-85. (CPCRI, Kasaragod, Kerala).

A review and discussion under the

following headings: microorganisms in relation to plant growth and productivity; microorganisms in processing and product diversification; coconut water as a substrate for microbial cultivation; microbial deterioration of coconut products; and research needs.

604. THOMAS, GEORGE, V.; SHANTARAM, M.V. and SARASWATHI, N. 1985. Occurrence and activity of phosphate solubilizing fungi from coconut plantation soils. *Pl. Soil* 87(3): 357-64. (CPCRI (RS), Kayangulam, Kerala).

The occurrence of phosphate-solubiliz-

ing fungi in coconut plantation soil types was investigated. The laterite, alluvial and clayey soils harboured more of the P-solubilizing fungi than the sandy soils. The isolated P-solubilizing fungi solubilized 26 to 74% of the tricalcium phosphate in 5-15 days. The competitive saprophytic ability of the active P-solubilizing fungi in soil varied between the isolates. Eight fungi with high P-solubilizing capacity and high competitive saprophytic ability were recognised. They have better capacity to survive in soil and express their role in P-solubilization.

## 8.2 Mycorrhiza

605. HARIKUMAR, V.S. 1990. Vesicular-arbuscular mycorrhizal association in coconut in relation to management practices. M.Phil. dissertation. Mangalore University, Mangalore. 120 p. (CPCRI, Kasaragod, Kerala).

Mycorrhizal status of three genotypes of coconut viz., WCT, COD x WCT and WCT x COD was studied at different levels of fertilizers under irrigated and rainfed conditions. There was 32.7% reduction in VAM colonisation at the recommended level of fertilizers and 55.5% reduction at the higher level of application. WCT was superior to the two hybrids in harbouring VAM in roots. Palms which received irrigation in summer months had greater level of VAM colonisation when compared to unirrigated palms. Mycorrhizal colonisation in roots and spore density in the root region soils of coconut were found to be affected under the treatments of tillage, herbicide, fertilizers and a combination of tillage+organic and inorganic manures when compared to that in palms which were not receiving these treatments. Identification of the VAM fungi associated with coconut under different management treatments revealed the occurrence of nine species of VAM fungi belonging to the three genera viz., *Glomus*, *Acanlospora* and *Gigaspora*. Testing of the indigenous isolates of VAM fungi for their efficacy to increase growth revealed large variation in the growth promoting efficiency of different cultures on *Calopogonium*.

606. RAMESH, C.R. 1984. Root infection and population density of VA mycorrhizal fungi in a coconut based multistoreyed cropping system. In: Symposium on Plantation crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.548-554. (CPCRI,

Kasaragod, Kerala).

Spores of vesicular-arbuscular (VA) mycorrhizal fungi were found in all the soil samples collected from the root zones of plants forming a coconut based multistoreyed cropping system, namely coconut, cacao, cinnamon and black pepper. Their numbers ranged widely from plant to plant (8-420 spores/100 g soil) and varied remarkably from sample to sample of the same crop. Of the eight species found, *Gigaspora gigantea*, *G. gilmorei*, *Glomus fasciculatus* (clusters), and *G. macrocarpa* were most common. Usually more than two VA species occurred at the root zone of each crop. Root samples of all the hosts showed extensive infection (80-90%) with internal and external hyphae, and characteristic vesicles and arbuscules.

607. SASIDHARAN, N.K.; VARGHESE, ABRAHAM and SIVAPRASAD, P. 1988. Impact of weed control methods on the occurrence and intensity of weed flora and mycorrhizal association in coconut. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.44. (RCRS, KAU, Kumarakom, Kerala).

In coconut gardens of the reclaimed alluvial soils of Kumarakom, chemical and mechanical methods of weed control alone and in combination were tried for four years from 1984 to 1988. The treatments had significant effect on the occurrence and intensity of various weed species and microflora. Perennial graminaceous weeds dominated in treatments receiving paraquat alone and in combination with 2, 4-D sodium salt. Graminaceous weeds could be significantly controlled with dalapon application. The mechanical methods of weed control resulted in the recurrence of a number

of weed species. The mycorrhizal colonisation studies indicated that the chemical weed control did not influence the VAM colonisation. The incorporation of 2, 4-D sodium salt stimulated the VAM intensity in the root and rhizosphere soil of weed plants and coconut. Weed control by cultural means generally reduced the VAM colonisation in the weed plants and coconut.

608. THOMAS, GEORGE, V. 1987. Microbial population, enzyme activity and VA mycorrhiza in the root region of coconut in relation to in situ green manuring. In: Symposium on Plantation Crops, 6th, RR11, Kottayam, Dec. 16-20, 1984. Proceedings of PLACROSYM VI. Edited by M. R. Sethuraj and others. p. 267-274. (CPCRI, Kasaragod, Kerala).

In situ cultivation and incorporation of green manure legumes in coconut basins improved the microbial activity in the root region of coconut in a slightly acidic laterite soil. Population of bacteria, fungi, actinomycetes, asymbiotic nitrogen fixing and phosphate solubilising bacteria were significantly increased during the maximum vegetative phase and at 30 days of incorporation of green manures. However, such a proliferation in microflora was not observed at 60 days of incorporation. Dehydrogenase activity also exhibited a similar trend, whereas the activity

of urease enzyme did not increase to any significant level. The number of endomycorrhizal chlamydo spores in the root region soil and the intensity of mycorrhizal infection in roots of coconut were high in green manured basins. In general, *Pueraria phaseoloides* had a better beneficial influence on microbial characteristics of coconut root region as compared to *Mimosa invisa* and *Calopogonium mucunoides*.

609. THOMAS, GEORGE, V. and GHAI, S.K. 1987. Genotypic dependent variation in vesicular-arbuscular mycorrhizal colonisation of coconut seedlings. *Proc. Ind. Acad. Sci. (Pl. Sci.)* 97(4): 289-294. (CPCRI, Kasaragod, Kerala.)

In a study of one-year-old seedlings of 17 tall and dwarf cultivars and four hybrids, growing on a sandy loam soil, the proportion of root segments with vesicular-arbuscular mycorrhiza ranged from 56.8 to 95.2%, being highest in the tall Laccadive Ordinary and significantly higher in the tall cultivars than in the dwarfs or hybrids. Similar trends were observed for infection grading (measure of colonization intensity) and for numbers of spores in the soil around the seedlings. The extent of mycorrhizal colonization also varied between root segments within a cultivar. Mycorrhizal species observed included three of *Gigaspora* and two of *Glomus*.

## 9. MIXED CROPPING

610. ANILKUMAR, A.S. and PILLAI, S.J. 1988. Prospects of mixed cropping, cocoa and clove with coconuts. *Indian Cocoa, Arecanut Spices J.* 12(2): 36-37. (Instructional Farm, College of Agric., KAU, Trivandrum, Kerala).

Cocoa and clove seedlings were planted in a West Coast Tall coconut plantation as intercrops. Maximum increase in coconut yield was obtained by intercropping with clove, followed by inter cropping with cocoa, with the lowest yield from a coconut monoculture (control). The coconut yield increment in intercropped plots was attributed to addition of organic residues from the intercrops.

611. BASTINE, LATHA; KHADER, ABDUL and RAJAMONY, L. 1986. Cost-benefit analysis of intercropping of cocoa in coconut gardens. *Madras Agric. J.* 73(3): 170-172. (RARS, KAU, Pilicode, Kerala).

Cocoa was planted in single and double rows in a 50-year-old coconut garden spaced at 9 x 9 m. In control plot coconut palms were grown in monoculture. Each crop was fertilized separately. Coconut yields were recorded for the 6 monoculture years (1967-70) and for the 13 intercropping year (1971-83). Intercropping with cocoa had no adverse effect on coconut yields, and the returns from double hedge cocoa were more than double than from single hedge cocoa rows.

612. BAVAPPA, K.V.A.; KAILASAM, C.; KHADER, K.B. ABDUL; BIDDAPPA, C.C.; KHAN, H.HAMEED; KASTURI BAI, K.V.; RAMADASAN, A.; SUNDARARAJU, P.; BOPAIAH, B.M.; THOMAS, GEORGE, V.; MISRA, L.P.; BALASIMHA, D.; BHAT, N.T. and BHAT, K. SHAMA. 1986. Coconut and arecanut based high density multispecies cropping systems. *J. Plantn Crops* 14(2): 74-87. (CPCRI, Kasaragod, Kerala).

In Kerala, India, high density multispecies cropping models were laid out, one each in coconut and arecanut plantations during 1983. The yield of coconut and arecanut increased to the extent of 176% and 125%, respectively, in the 2 intercropping systems. The air space utilization was 31% in coconut while it was 63% in the arecanut system. There was a substantial increase in coconut biomass while the biomass of other crops remained more or less the same.

Depletion in N and Mg was indicated. In general, there was a build-up of P and K nutrients in the systems. Under the arecanut system N also showed an increase. There was improved microbial activity in the systems. No serious pest and disease management problems were indicated. A number of crop varieties and hybrid tolerant/resistant to the nematode pathogen could be identified. The interaction of various factors for exploiting higher levels of productivity and the need for crop choices based on crop performance are discussed.

613. BHENDIA, M.L. and GOVINDAN, C. 1979. Why not a pasture in coconut garden. *Intensive Agric.* 17(10): 24-27. (Regional Station for Forage Production Demonstration, Avadi, Madras, T.N.).

Pasture management under coconut is the same as in open grasslands. However, a few facts must be taken under consideration. The forage crops chosen should have shade tolerance and salinity tolerance. Fertilizers are to be added to both pasture and coconut. These aspects are discussed as well as pasture productivity. Grasses performing well under reduced light conditions are *Brachiaria milliformis*, *B. brigantha*, *Pennisetum purpureum*, *Panicum maximum* and *Setaria sphacelata*.

614. BOPAIAH, B.M. 1981. The advantages

of growing legume intercrops in coconut gardens. *Indian Cocon. J.* 11(11): 5-6. (CPCRI (RS), Vittal, Karnataka).

The author evaluates the advantages of growing legumes as an intercrop in coconut gardens in India. The possibilities of growing different legumes such as grain legumes, green manure crops, cover legumes, forage legumes are discussed.

**615. CENTRAL PLANTATION CROPS RESEARCH INSTITUTE, KASARAGOD.** 1979. Multiple cropping in coconut and arecanut gardens. Edited by E.V. Nelliath and K. Shama Bhat. Technical Bulletin no. 3. Kasaragod: CPCRI. 54p. (CPCRI, Kasaragod, Kerala).

This bulletin is based on the results achieved in the past from a number of experiments conducted on coconut and arecanut based farming systems in India. Techno-economic feasibilities of these systems have been discussed.

**616. GEORGE, S. and NAIR, R.V.** 1987. Effect of shade on growth, nodulation and yield of cowpea (*Vigna unguiculata* (L) Walp). *Agric. Res. J. Kerala* 25(2): 281-284. (College of Horticulture, KAU, Trichur, Kerala).

In a field trial in May-Oct. 1981 to test the feasibility of growing *Vigna unguiculata* with coconuts, *V. unguiculata* cv. Kanakamani plants were artificially shaded by 0, 25, 50 or 75%. Yields for 0, 25, 50 and 75% shading were 1.57, 0.66, 0.40 and 0.15 t/ha, respectively while DM production was less affected by shading. LAI was not affected up to 60 days after sowing after which it rapidly declined. The detrimental effects of shading on LAI, specific leaf area, leaf wt. ratio, nodulation and NAR are also briefly discussed. It was concluded that *V. unguiculata* would not be suitable for growing under coconuts.

**617. GOPALASUNDARAM, P. and NELLIATH,**

**E.V.** 1979. Intercropping in coconut. *In: Multiple cropping in coconut and arecanut gardens.* Edited by E.V. Nelliath and K. Shama Bhat. Technical Bulletin no. 3. Kasaragod: CPCRI. p.6-23. (CPCRI, Kasaragod, Kerala).

This article covers the prospects of intercropping tubers, cereals, millets, pulses, oilseeds and fruit crops. The authors observed that among several intercrops tried in different locations in India, tubercrops in general were more profitable.

**618. KANNAN, K. and SUDHAKARA, K.** 1977. Interplanting cocoa in coconut garden. *Indian Cocon. J.* 8(4): 1-3. (Coconut Res. Station, KAU, Pilicode, Kerala).

A trial was conducted at the Coconut Research Station, Pilicode from 1970 onwards to find out the effect of interplanting coconut garden with cocoa in rows. Analysis of yield data 6 years have shown significant increase in yield of coconut from the mixed cropping system.

**619. KHADER, ABDUL; RAJAMONY, L. and BALAKRISHNAN, P.C.** 1984. Effect of raising cocoa as a mixed crop in adult coconut plantations. *In: Symposium on Plantation Crops, 6th, RRII, Kottayam, Dec. 16-20, 1984.* Proceedings of PLACROSYM VI. Edited by M.R. Sethuraj and others. p.367-374. (RARS, KAU, Pilicode, Kerala).

In a mixed cropping trial with cocoa in a coconut garden under unirrigated conditions, observations were made on the yield of coconut and cocoa from 1965 to 1983. Cocoa, as a mixed crop in a coconut garden, had not influenced the yield and the bearing habit of coconut. The double hedge system of cultivation of cocoa in the interspaces of coconut was found to be superior to the single hedge with respect to the yield and economic return obtained per ha. Even in the double hedge system of raising cocoa under coconut, no crop

or plant competition was observed.

620. KUMAR, A.S.A. and PILLAI, S.J. 1990. Potential and prospects of amaranth as an intercrop in coconut nursery. *Indian Cocon. J.* 20(10): 8-9. (College of Agric., KAU, Trivandrum, Kerala).

To utilize the soil space between seed coconuts (sown at 30 x 30 cm) during the first 3 months after sowing, vegetable amaranth (*Amaranthus* sp.) was sown in 4 different ways (dibbling, flow line, broadcast and criss-cross). The flow line method at 1.5 kg seeds/ha gave the highest leaf yield of 26.9 t/ha; the broadcast method at 2 kg seeds/ha gave the lowest yield (20.1 t/ha).

621. KURIAN, T.M. 1979. Multistoreyed cropping in coconut gardens of Kerala. *Indian Cocon. J.* 10(3): 7-8. (College of Horticulture, KAU, Trichur, Kerala).

The scientific principle of the multistoreyed cropping is to use the basic production inputs such as water, light and nutrients to a maximum level. Long term researches have helped scientists to develop good crop combinations like coconut + pepper + cocoa + pineapple.

622. LEELA, K. and BHASKARAN, U.P. 1978. Effect of intercropping coconut stands with groundnut on soil fertility and plantation management. In: Symposium on Plantation Crops, 1st, RRIL, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p.393-398. (KAU, Trichur, Kerala).

Growing groundnut as a rainfed intercrop in coconut stand registered a net additional income of Rs. 2772 per ha, realised through the sale of intercrop produce and savings in expenses effected by skipping certain cultural operations and inputs to the main crop. The cost-benefit ratio worked out to 1:1.6. In-

tercropped plot recorded higher N, P, K and Ca status after harvest of groundnut. The spreading habit of this 'floor crop' significantly suppressed weed growth and reduced splash erosion. This cropping system also generated additional employment for about 20 men and 85 women. Groundnut can thus be considered as a compatible intercrop in coconut stands.

623. LOUIS, I. HENRY and NARAYANAN, K.M. 1965. It pays to raise intercrop in coconut gardens. *Cocon. Bull.* 19(1): 3-7. (TNAU Subcentre, Veppanakulam, T.N.).

Farmers of Pollachi area in Tamil Nadu state, grow plantains, groundnut, turmeric, sorghum, cotton, ragi and sugarcane as intercrops with profit.

624. MARKOSE, V.T. and NANDA KUMAR, T.B. 1979. Cocoa under coconut; a boon to farmers. *Indian Cocon. J.* 9(9): 1-5. (Coconut Development Board, Cochin, Kerala).

An interview of a farmer who has mixed cropping of coconut and cocoa in his garden is highlighted in this article.

625. MATHEN, K.; THOMAS, P.K. and GEORGE, T.G. 1978. Fish culture as a means of additional income to coconut growers. *Indian Cocon. J.* 9(2): 4-5, 14. (CPCRI (RS), Kayangulam, Kerala).

A pilot trial was carried out in 28 ponds of 1-3 cents in Krishnapuram village near Kayangulam. From this the recovery was upto 100, 73, 90% respectively for Cyprinus, Mrigal and Fimbriapa. Cyprinus grow upto a maximum weight of 1.2 kg in 7 months time and found to be profitable.

626. MATHEW, JACOB and SHAFEE, MOHAMMED. 1979. Mixed farming in coconut garden. In: Multiple cropping in coconut and arecanut gardens. Edited by E.V. Nelliath and K. Shama Bhat. Kasaragod: CPCRI. Technical Bulletin no. 3. p.42-46. (CPCRI, Kasaragod, Kerala).

The mixed farming experiment laid out during 1972 at CPCRI, Kasaragod have been analysed to determine its economic viability. The analysis reveals that the incremental benefits generated through this system in one hectare coconut garden was of the order of Rs. 22762 as on 1979.

627. NAIR, M.K. and GOPALASUNDARAM, P. 1990. Coconut based farming systems for humid tropics. *In: Indian Science Congress Association, 77th Session, Cochin, 1990.* p.93-94. (CPCRI, Kasaragod, Kerala).

Describes the agroecological conditions of West Coast of India and various coconut based farming systems and their economics.

628. NAIR, P.K.R. 1977. Multispecies crop combinations with tree crops for increased productivity in the tropics. *Gartenbauwissenschaft* 42(4): 145-150. (CPCRI, Kasaragod, Kerala).

Various systems for making the best use of the light energy falling on to crop plants are described using coconut plantation as examples. Four systems are described: (1) intercropping with annual; (2) mixed cropping with other perennial crops such as cacao, clove, nutmeg and black pepper; (3) multistoreyed cropping in which coconut black pepper + cocoa + pineapple were planted so that each crop produced a canopy at a different height; (4) mixed farming with a small area of coconuts and a few animals with pasture legumes and grass grown in the interspaces of coconut.

629. NAIR, P.K.R. 1979. Intensive multiple cropping with coconut in India; principles, programmes and prospects. West Berlin: Verlag Paul Parey. *Advances in Agronomy and Crop Science*, 6. 147p. (ICRAF, Nairobi, Kenya).

The book not only reviews the past experimental results, but also brings out the high degree of the complexity of multiple cropping in coconut gardens.

630. NAIR, P.K.R. 1983. Agroforestry with coconuts and other tropical plantation crops. *In: Plant research and agroforestry.* Edited by P.A. Huxley. Nairobi: ICRAF. p. 79-101. (ICRAF, Nairobi, Kenya).

In this review, cereals, pulses, root crops, species and condiments, fruits, tree and other crops, and common pasture and forage sp., commonly grown under coconuts in many parts of the world have been listed. Yields, economic aspects and complementarity of the crops are discussed.

631. NAIR, P.K.R. and BALAKRISHNAN, T.K. 1977. Ecoclimate of a coconut plus cacao crop combination on the West Coast of India. *Agric. Met.* 18(6): 455-462. (CPCRI, Kasaragod, Kerala).

Daily variations in temperature, vapour pressure, relative humidity and evaporation were measured at 0, 100 and 200 cm above ground level in plantations of unirrigated and irrigated monocrops of coconut. for two consecutive seasons. The ecoclimate in the crop combinations showed a buffering effect against marked diurnal variation, and differences between the average daily maximum and minimum temperatures and RH were considerably less than in monocrops of coconut or near uncropped soil. Evaporation from the crop combination was only about 30% of that from uncropped soil.

632. NAIR, P.K.R. and VARGHESE, P.THOMAS. 1976. Crop diversification in coconut plantations. *Indian Fmg* 25(11): 17-19. (CPCRI, Kasaragod, Kerala).

Intercropping coconut with annual and perennial crops, mixed cropping with perennials and multistoreyed cropping were studied. Tubers, because of their short duration, easy relative management and high calorie output have great potential as intercrops. Cacao is most suitable for mixed cropping as it can be

planted as a double hedge of 2 rows in between the rows of coconut. The multi-storeyed crop combination comprises coconut-black pepper-cacao-pineapple. In an existing coconut plantation of 175 palms/ha 600 cacao plants and 3,500 pineapple plants can be accommodated in addition to the black pepper trailed on each palm. Agronomic merits, input requirements and economic advantages of these cropping patterns are discussed.

633. NAIR, P.K.R. and VARGHESE, P.THOMAS. 1980. Recent advances in the management of coconut based ecosystems in India. *Trop. Ecology Develop.* p.569-580. (CPCRI, Kasaragod, Kerala).

A major scientific initiative in recent years, aimed at increasing the productivity of the coconut areas, is the intensification of land use through combination of compatible crops (and sometimes animals) under or between the palms. Considerable progress has been achieved in identifying the crops that grow well with coconuts and perfecting the agrotechniques of such combination cultures, and the farmers are taking up the practice in a big way. Ecological implications of these new initiatives in the management of the coconut-based ecosystem are examined.

634. NAIR, P.K.R.; VARMA, R.; NELLIAT, E.V. and BAVAPPA, K.V.A. 1975. Beneficial effects of crop combination of coconut and cacao. *Indian J. agric. Sci.* 45(5): 165-171. (CPCRI, Kasaragod, Kerala).

A 16-year-old coconut plantation, with palms spaced at 7.5 x 7.5 m, was interplanted with cacao either as single or double rows alternating between the coconut rows, with 3.5 and 2.5 m, respectively, between the plants. With cacao there was little difference between the 3-year growth of single-row and double-row interplants. In the fourth year, however, single-row interplants grew better and they

produced more pods/plant and a greater weight of fresh beans/plant. With coconuts, cropping after 3 years was markedly enhanced by double-row interplants, compared with their yields before interplanting, indicating a synergistic effect.

635. NAIR, R.V. 1979. Multiple cropping in coconut gardens. *Indian Fmg* 12(11-12): 35-37. (College of Horticulture, KAU, Trichur, Kerala).

Technical feasibilities of inter/mixed croppings in coconut gardens have been discussed.

636. NANDA KUMAR, T.B. 1978. A success story in multiple cropping. *Indian Cocon. J.* 9(6): 1-6. (Coconut Development Board, Cochin, Kerala).

Success story of farmer who grew cocoa, coffee, pepper, nutmeg, banana, tapioca, etc. mixed with coconut is discussed.

637. NANDA KUMAR, T.B. 1980. Thriving farm of a daring farmer. *Indian Cocon. J.* 10(11): 1-4. (Coconut Development Board, Cochin, Kerala).

Interview story of a farmer who has cultivated coconut as a monocrop and cocoa mixcropped with arecanut is highlighted.

638. NEELAKANTAN POTTY, N.; ASOKAN, P.K. and RADHAKRISHNAN, T.C. 1979. Performance of nine varieties of turmeric (*Curcuma longa* L.) in coconut gardens. *Agric. Res. J. Kerala* 17(1): 130-132. (RARS, KAU, Pilicode, Kerala).

It was found that "Sugandam" Wynad local and *T. Sunder* are yielding better than other varieites when grown as intercrop with coconut.

639. NEELAKANTAN POTTY, N.; RADHAKRISHNAN, T.C. and ASOKAN, P.K. 1979. A note on the early growth and performance

of six varieties of pepper in the multistoreyed cropping programme in coconut gardens. *Agric. Res. J. Kerala* 17(1): 151-152. (RARS, KAU, Pilicode, Kerala).

Out of six varieties tried as intercrops, Karimunda and Panniyur 1 excelled in early growth stages.

640. NELLIAT, E.V. 1979. Multistoreyed cropping. *In: Multiple cropping in coconut and arecanut gardens*. Edited by E.V. Nelliath and K. Shama Bhat. Kasaragod: CPCRI. Technical Bulletin no. 3. p.39-41. (CPCRI, Kasaragod, Kerala)

The paper discusses the technical feasibility of coconut based multistoreyed cropping, tried at CPCRI, Kasaragod, involving cocoa, cinnamon, pepper and pineapple. From this study it was found that coconut, black pepper, cocoa, pineapple combination is most ideal under irrigated conditions.

641. NELLIAT, E.V. 1984. Crop mixing in coconut holdings. *Indian Cocon. J.* 15(3 & 4): 12-16. (CPCRI, Kasaragod, Kerala).

Possibility of adopting inter and mixed cropping systems in coconut plantations in Kerala is discussed. When determining the cropping system light profile, root habit, agronomic desirabilities, ecoclimate, soil fertility, employment generation and returns are taken into consideration with proper selection of crops to be grown under varying conditions.

642. NELLIAT, E.V.; GOPALASUNDARAM, P.; VARGHESE, THOMAS, P. and SIVARAMAN, K. 1979. Mixed cropping in coconut. *In: Multiple cropping in coconut and arecanut gardens*. Edited by E.V. Nelliath and K. Shama Bhat. Kasaragod : CPCRI. Technical Bulletin no. 3. p.28-34. (CPCRI, Kasaragod, Kerala).

The prospect of growing coca and black pepper has been discussed. This paper also highlights the effects of raising cocoa under

coconut in respect of soil fertility, microbial activity and microclimate.

643. NELLIAT, E.V. and KRISHNAJI, N. 1976. Intensive cropping in coconut gardens. *Indian Fmg* 27(9): 9-12. (CPCRI, Kasaragod, Kerala).

Intercropping and mixed cropping model programmes including tubers, black pepper, pineapple, cocoa and banana are discussed and net annual returns/ha are tabulated for each. The most important limiting factors are management practices, palm age and palm spacing.

644. POTTY, V.P. 1977. Effect of crop mixing on the coconut rhizosphere. *Indian Cocon. J.* 8(7): 1-21. (CPCRI (RS), Kayangulam, Kerala).

The objective of the investigation was to derive data as to how best an intercropping of hybrid napier with the coconut palm would influence the rhizosphere of the main crop. The significant increase in the number of bacterial population in the rhizosphere of palms cultivated with the fodder grass might influence the pathogenic flora. The abundance of saprophytes in the rhizosphere normally exerts an adverse influence in pathogenic infection. Reports are conflicting on the occurrence of *Azotobacter* in the rhizosphere of different plants. General conclusions seem to suggest that plant roots do not favour the development of this group. Soil ecosystems with a pH lower than 6 are relatively free of this group. The higher number of nitrogen fixing bacteria in the rhizosphere of the palms suggests the possible occurrence of the nitrogen fixing bacteria other than *Azotobacter*. The abundance of phosphate solubilising bacteria in the rhizosphere is in agreement with numerous observations. Their increased number in experimental palms and particularly in root(wilt) affected palms can be attributed to the pattern of root exudates in the environment, that can act favourably for colonization.

645. PUSHKARAN, K.; BABYLATHA, A.K. and GEORGE, K.M. 1985. Comparative performance of turmeric varieties in coconut gardens. *South Indian Hort.* 33(4): 269-290. (Banana Res. Station, KAU, Kannara, Trichur, Kerala).

In 3 year trials, 14 turmeric (*Curcuma longa*) cultivars were grown in coconut (var. WCT) plantation, with the palms spaced at 8 x 8 m. The cv. Amruthapani Kothapetta (A) 72 gave the highest total yield of 17.36 t/ha and is recommended for intercropping. The cv. Ventimetta gave the lowest yield of 4.78 t/ha.

646. PUSHKARAN, K.; JOSEPH, TESSY and SASIDHAR, V.K. 1990. Sanramon coffee is a good intercrop for rainfed coconut garden. *Indian Cocon. J.* 21(6): 5-6. (Banana Res. Station, KAU, Kannara, Trichur, Kerala).

This study reveals that no much differential effects have made by coffee cultivars on the main crop. The weed growth in the garden was suppressed because of the intercrop and the average yield of Sanramon during 10th year of planting was 629 kg dry beans per hectre. Hence Sanramon can be utilized as an intercrop in rainfed coconut garden.

647. PUSHKARAN, K.; SUMA, A. and BABYLATHA, A.K. 1989. Suitable banana cultivars for intercropping in coconut gardens in Kerala. *Banana Newsletter (Australia)* 12: 20-21. (Banana Res. Station, KAU, Trichur, Kerala).

The performance of 16 banana cvs. as an intercrop in a coconut garden was studied in a field trial in Kerala, India. None of the cvs. affected the performance of the coconut palms. The cultivar Booditha bontha batheesa had the highest productivity, closely followed by Kanchikela, Karpooravelly and Palayankodan. The highest net profit was provided by cv Poovan, followed by Chenkadali, Karpooravally, Palayankodan and Njalipoovan. There were

considerable different in the quality of produce from different cvs. When banana is planted only for household purposes, all cvs. with a satisfactory yield could be grown.

648. RAJAGOPALAN, A.; VISWANATHAN, T.V. and NIRMALA DEVI, S. 1990. Medicinal plants as intercrops in coconut garden. In: Symposium on Plantation Crops, 9th, CCRI, Chikmagalur, Dec. 5-7, 1990. Abstracts of papers. p.11. (RARS, KAU, Pilicode, Kerala).

Performance of all species except *C. vetiveroides* was better under partial shade of coconut. In terms of net returns per hectare, *C. vetiveroides* stood first, followed by *Maranta arundinacea* and *Kaempferia salanga*.

649. RAJAMONY, L. and NAIR, J.B. 1981. Utilize your coconut interspace profitably. *Indian Fmrs Dig.* 14(12): 32-34. (Banana Res. Station, Kannara, KAU, Trichur, Kerala).

It is observed that the intercrops minimise soil temperature by covering soil and usual cultural operations done in the interspaces of coconut garden are made use of in raising intercrops. Hence additional input is not required in abundance under coconut based intercropping system. Among the intercrops Banana, Turmeric and Tapioca were found to be better remunerative.

650. RAJAN, K.C.; KUNJU, U. MOHAMMED, GEETHAKUMARI, V.L. and SYRIAC, K. ELIZABETH. 1988. Intercropping banana varieties in coconut gardens. *Agric. Res. J. Kerala* 26(1): 79-84. (RARS, KAU, Kumarakom 686 566, Kerala).

Different local varieties of banana are being cultivated by the farmers as intercrop in coconut garden. Ratooning is also followed by them. Information on the performance of different varieties and on the effect of ratooning of these varieties when grown as intercrops in coconut gardens of Kuttanad is very little.

Preliminary trials conducted at the Regional Agricultural Research Station, Kumarakom during 1979-'81 revealed that among the varieties Palayanthodan, Monthan and Padatty were found promising in terms of yield when grown as an intercrop in coconut gardens. This investigation was therefore conducted to select the variety suitable for intercropping in coconut gardens of Kuttanad and to assess the economic feasibility of ratooning of different varieties in the area.

651. RAMANATHAN, T. 1985. Banana is profitable intercrop in coconut. *Indian Cocon. J.* 16(5): 6-11. (Coconut Res. Station, TNAU, Veppankulam, T.N.).

Cacao and six banana cultivars in various combinations were grown as intercrops with coconut cv. East Coast Tall, between 1980 and 1983. Intercropping with cocoa slightly increased coconut yield, but a substantial increase occurred with banana. Two rows of banana (cv. poovan) planted between the coconut palm rows gave the highest net increase in coconut yield over control (30.4%) and also the highest intercrop yield.

652. RAMANATHAN, T.; CHANDRASEKARAN, N.R. and RAMACHANDRAN, M. 1982. Intercropping in coconut. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.448-453. (School of Genetics, TNAU, Coimbatore, T.N.).

Results of intercropping experiments carried out at the Coconut Research Station, Veppankulam in east coast of Tamil Nadu, are discussed. Cocoa and pineapple are unlikely to be economic as intercrops, whereas banana grown well and is profitable if the market demand is good. All varieties of banana, culinary and table ones, behave similarly and the choice of variety should be based on local market

demands, and its resistance to damage by cyclone which is of common occurrence during monsoon months.

653. RAMANUJAM, T.; INDIRA, P. and NAIR, G.M. 1984. Productivity of cassava under shade. *Indian Fmg* 33(12): 39-40,42. (CTCRI, Trivandrum, Kerala).

Reduction in tuber yields of 6 cassava varieties due to shading caused by intercropping them in 30-yr-old coconut plantation varied between varieties, reduction in yield, being lowest in H-165.

654. RAO, H.H. 1986. Mixed farming in coffee. *Indian coffee* 50(1): 15-18. (Coffee Board, Bangalore, Karnataka).

Coffee, being a semi-silvicultural plant requires a tree cover under Indian circumstances. Such a situation paves the way for bringing about the association of coffee with other crops. A normal shade canopy adds 20,000 kg of leaf litter per ha annually. The advantages of various plants grown as associate crops such as forest trees, citrus, banana, pepper and coconuts, are discussed. It is concluded that returns from associate cropping are bound to augment considerably the earning of small farms.

655. REDDY, K. VENKAT SUBBA; SARMA, K.; NAGARAJA, K. and DASARATHI, T.B. 1989. Banana as an intercrop in coconut plantations of central Godawari Deltas (A.P.). *Andhra Agric. J.* 27(5-6): 326-327. (Coconut Res. Station, APAU, Ambajepet, Godawari District, A.P.).

Significance of intercropping banana with coconuts has been discussed in the light of increased income through increased yield performance of major crop.

656. SALAM, M. ABDUL and SREEKUMAR, D. 1990. Coconut based mixed farming system to sustain productivity. *Indian Cocon. J.* 20(10): 3-5. (NARP (special station). KAU, Sadanandapuram, Kottarakkara, Kerala).

A case study of coconut based farming system in Trivandrum district reveal that a farmer possessing 68 cents of land earns about Rs. 25,000 gross margin/year from the sale of an average of 7,000 coconut and about 2,000 litres of milk. The farmer believes that the practice of mixed farming improves the soil health condition of coconut garden for sustainable agriculture.

657. SALAM, ABDUL M.; SREEKUMAR, D. and MAMMEN, M.K. 1990. Mixed farming on homestead agriculture; an economical approach. *Indian Fmg* 40(5): 14-16. (NARP (Special Station), KAU, Sadanandapuram, Kottarakkara, Kerala).

Integrated farming system taken up by farmers of Kerala for achieving high level productivity by combining a multitier cropping system, a livestock system and irrigation system in their homestead are discussed.

658. SATHEESAN, K.V. and RAMADASAN, A. 1982. Growth and productivity of turmeric grown as a pure and as an inter crop in coconut garden. *In: National Seminar on Ginger and Turmeric; Calicut, Apr. 8-9, 1980.* Ginger and turmeric, proceedings. Edited by M.K. Nair and others. p.69-75. (CPCRI, Kasaragod, Kerala).

Relative performance of turmeric selection no. 24 raised as an intercrop in coconut gardens and as a pure crop was assessed during 1977-78 cropping season. The leaf area development and crop growth rate (CGR) reached their maximums much earlier in the pure crop than in the intercrop. The difference in growth rate during the initial period of rhizome development was reflected in the significant difference observed in the final yield of the intercrop (4.8 t/ha) and pure crop (7.0 t/ha). The yield superiority observed in the pure crop is attributed to the higher CGR during tuberisation and higher solar energy input under open conditions during this period.

659. SHANTHAMALLAIAH, N.R.; GOWDA, VENKATESHA T.N., KRISHNA MANOHAR, R. and SHIVA YOGISHWAR, B. 1984. Studies on intercropping coconut with different field crops in Maidan Tract of Karnataka. *In: Symposium Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982.* Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.402-404. (AICCAIIP, Agricultural Res. Station, UAS, Ariskere - 573 103, Karnataka).

Intercropping trials taken up with eleven crops in coconut plantations showed that the maximum net income/ha was obtained with Chilli (Rs. 8784) followed by Ragi (Rs. 6473), Pata (Rs. 6181) and Bengalgram (Rs. 6116). In the six double cropping sequence systems, the maximum net income/per ha was obtained with Potato-Wheat (Rs. 12801), followed by French Beans-Wheat (Rs. 12,750), and Ragi-Wheat (Rs. 9,208) systems. There was no deleterious effect on coconut crop due to intercropping. The employment opportunities also increased on an average by 204 days in single intercropping and by 479 days in double cropping sequence systems.

660. SINGH, SHYAM.; GAJJA, B.L. OMPRAKASH and SINGH, SHIVADHAR. 1988. Economics of intercropping in coconut plantations with tuber crops in South Andaman. *J. And. Sci. Assoc.* 4(1): 79-80 (CARI, Port Blair, A & N Islands).

Since coconuts occupy 40% of the cultivated land and do not start cropping until 5 to 7 years after planting, returns from the land are low. In trials carried out between 1978 and 1987, coconuts were intercropped with 5 crops, with monoculture as the control. The total net incomes (intercrop + coconut) over the years were: coconut alone, Rs. 5,000; coconut with cocoyam (*Dioscorea*), Rs. 7104; with elephant foot yam (*Amorphophallus campanulatus*), Rs. 10704; with tapioca (*Manihot esculenta*), Rs. 6570; with turmeric (*Curcuma*

*longa*), Rs. 6710; and with ginger (*Zingiber officinale*) Rs. 9955.

661. SUMA, A.; PUSHKARAN, K.; BABYLATHA, A.K. and NYBE, E.V. 1989. Comparative evaluation of banana cultivars in coconut garden. *Indian Cocon. J.* 20(7): 6-9. (Banana Res. Station, KAU, Kannara, Trichur, Kerala).

Sixteen cultivars were assessed for intercropping with coconut in non-irrigated, partially shade conditions. Booditha Bontha Batheesa and Kanchikela gave the highest yields (8925 and 8890 kg/ha, respectively) but poovan, Chenkadali and Palayankodan produced the highest net profits per ha. As these varieties were shade tolerant they are also recommended for the homesteads of Kerala, India.

662. THOMAS, K.G. 1978. Cocoa; an ideal intercrop for coconut gardens. *Indian Cocon. J.* 9(4): 1-4. (Directorate of Cocoa, Arecanut & Spices Development, Calicut, Kerala).

Suitability of the interspace of the coconut lands for purpose of other cropping is discussed. Beneficial effects of growing cocoa under coconut different ways of planting cocoa and details on manuring and pests & diseases of the crops are also discussed.

663. VARGHESE, P. THOMAS; NAIR, P.K.R.; NELLIAT, E.V.; RAMA VARMA and GOPALASUNDARAM, P. 1978. Intercropping with tuber crops in coconut garden. In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath & others. p.399-415. (CPCRI, Kasaragod, Kerala).

Intercropping in coconut stands with tubers revealed that raising tuber crops has no adverse effect on the main crop of coconut, provided, the same intercrop was not grown on the same plot every year and that both

the intercrop and the main crop were manured adequately and separately. Improvement in the yield of these crops was noticed in five year rotations. Among intercrops, elephant yam and ginger were the most profitable. Besides giving higher net returns per unit area, intercrops generated additional employment to the tune of about 130 man days/ha/year.

664. VARGHESE, P. THOMAS; NELLIAT, E.V. and BALAKRISHNAN, T.K. 1978. Beneficial interactions of coconut-cocoa crop combination. In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p. 383-392. (CPCRI, Kasaragod, Kerala).

A study on the amount of cacao litter added to the soil in a coconut-cacao crop mix was conducted at the CPCRI, Kasaragod. Shed leaves collected at fortnightly intervals for a one year period amounted to 818 and 1785 kg/ha/year (ovendry) under single and double hedge systems of planting, respectively. The organic carbon content and the soil fertility improved considerably under the crop mix, and was reflected in the enhanced yield of coconut.

665. VIJAYAKUMAR, K.R.; MAMMEN, G.; PILLAI, G.G. and VAMADEVAN, V.K. 1986. Alley cropping of *Leucaena* in coconut gardens in Western Ghats of India: yields of dry matter and organic nitrogen. *Leucaena Research Reports* 7: 72-74 (CWRDM, Calicut, Kerala).

In trials established in Aug. 1983 in Calicut, 4-month-old *L. leucocephala* seedlings were planted as 1 or 2 double-row hedges between 2 rows of coconuts. Yields of dry matter and organic N from 7 prunings showed that *L. leucocephala* can meet the requirements of green manure and mulching materials for coconut gardens.

## 10. PESTS

### 10.1 Insects

666. ABDURAHIMAN, U.C.; MOHAMED, U.V.K. and REMADEVI, O.K. 1981. Laboratory observations on the mating and oviposition behaviour of *Elasmus nephantidis* Rohwer. *Philipp. J. Cocon. Studies* 6(2):32-33. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Aspects of the reproductive behaviour of *Elasmus nephantidis*, a prepupal parasite of *Opisina arenosella* (*Nephantis serinopa*) are briefly described and discussed. Results of this study could have particular significance in utilizing *E. nephantidis* in the biological control of *O. arenosella* which infests coconut.

667. ABDURAHIMAN, U.C.; MOHAMED, U.V.K. and REMADEVI, O.K. 1982. Studies on the biology of a predator *Cardiastethus* sp. (Hemiptera: Anthocoridae) found in the galleries of *Nephantis serinopa* Meyr. (Lepidoptera: Xylorictidae). *Curr. Sci.* 51(11):574. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

A species of *Cardiastethus* (Hemiptera: Anthocoridae) predatory on the eggs and early larval instars of *N. serinopa* is recorded from Kerala. The predatory bugs have five nymphal instars all of which occupy an average of 18-22 days. The immature stages as well as the adults are predaceous but are non-specific having a range of hosts. The adults live on an average one month but may survive upto three months. Oviposition occurs throughout the life of mature females, each laying about 17-20 eggs.

668. ABDURAHIMAN, U.C.; MOHAMED, U.V.K. and REMADEVI, O.K. 1983. Studies on the biology of *Antrocephalus hakonensis* (Hymenoptera: Chalcididae); a pupal parasitoid of *Opisina arenosella* the coconut caterpillar. *Cocos* 1:11-16. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Observations are given relating to the biology, post-embryonic development and reproductive behaviour of *Antrocephalus hakonensis* (Ashmeed), a pupal parasitoid of *Opisina arenosella* Walker, the black-headed caterpillar pest of coconut.

The adult, before its escape from the host pupa emerges from its own pupal covering. In the laboratory. Adult females, when fed on 50% honey, lived for a maximum of 90 days while the males survived only for 46 days. Copulation was preceded by specific courtship displays. For oviposition, the females accepted both naked pupae as well as those within the cocoon inside the galleries of the host. Younger pupae however, were preferred by the parasite. A female lays only one egg at each act of oviposition, with an average of three eggs per day.

669. ABRAHAM, V.A.; KOYA, K.M. ABDULLA and KURIAN, CHANDY. 1989. Integrated management of red palm weevil (*Rhynchophorus ferrugineus* F.) in coconut gardens. *J. Plantn Crops* 16(Suppl.):159-162. (CPCRI (RS), Kayangulam, Kerala).

The red palm weevil, *Rhynchophorus ferrugineus* F., is a dreaded pest of the coconut palm, capable of killing the palm outright. Though different methods of management have been recommended against this pest, any single method has not been proved to be effective in combating the pest infestation. Timely adoption of curative chemical control can protect the palms from pest infestation. But being a tissue borer, the infestation is quite often detected at later stages only and as such it would be difficult to save the palm with the curative treatment. Hence, an integrated method of pest management system was

developed and tested in cultivators' garden in Alleppey district. The schedules included adoption of plant and field sanitation, prophylactic method of filling all the leaf axils of palms with BHC+ sand, curative chemical treatment, prevention of pest entry through cut ends of petioles and wounds and use of attractants. Sixty nine out of a total of 1005 young experimental palms were infested by the pest at the time of commencement of the experiment during 1970. By adoption of all the proven methods of weevil control in an integrated manner the pest infestation could be brought down near to zero level and the gardens could be maintained free of fresh infestation.

670. ABRAHAM, V.A. and MOHANDAS, N. 1988. Biology of coconut white grub *Leucopholis coneophora* Burm (Melolonthinae: Scarabaeidae: Coleoptera). *J. Plantn Crops* 16(1): 38–44. (CPCRI (RS), Kayangulam, Kerala).

The biology of the coconut pest *Leucopholis coneophora* was studied in field cages in Kerala, India. The incubation period averaged 23 days. The larval period averaged 260 and 270 days and the pupal period 25.3 and 25.7 days, for males and females, respectively. Males and females could be differentiated by the size of the antennal club. Adults emerged from the soil to mate at dusk and returned to soil within 25–30 minutes.

671. ABRAHAM, V.A. and MOHANDAS, N. 1988. Chemical control of the white grub *Leucopholis coneophora* Burm. a pest of coconut palm. *Trop. Agric.* 65(4):355–357. (CPCRI (RS), Kayangulam, Kerala).

Grubs of the white grub *Leucopholis coneophora* Burm. feed on the roots of coconut palms and is a severe pest in Kerala and Karnataka states in South India. Four chlorinated hydrocarbon insecticides, HCH, heptachlor, aldrin and chlordane were evaluated for control

of the immature stages of the white grub using bioassay techniques. Aldrin and heptachlor were the two most active compounds, weight for weight, against second and third instar grubs, but on a projected cost performance basis HCH and heptachlor emerged as the most promising candidates. Field evaluation of these two insecticides under controlled conditions proved that *L. coneophora* could best be controlled with heptachlor applied at 1.4 kg a.i./ha in the month of June or with HCH applied twice at 5 kg a.i./ha in June and September.

672. ABRAHAM, V.A. and MOHANDAS, N. 1990. Effect of different food plants on growth and development of the coconut white grub *Leucopholis coneophora* Burm. *J. Plantn Crops* 18(Suppl.):277–280. (CPCRI (RS), Kayangulam, Kerala).

Effect of different food plants on the development and biotic potential of the coconut white grub, *Leucopholis coneophora* was studied in specially designed field cages. Three-day-old first instar grubs were individually reared upto adult stage on coconut seedlings, cassava, cacao and wild sunn-hemp. Duration of different stages of *L. coneophora*, size and body weight, percentage survival, fecundity and viability of eggs were recorded. The duration of development was least in cassava and coconut followed by those in cacao and wild sunn-hemp. The observations indicated that cassava and coconut were more favourable hosts of *L. coneophora*. A higher build-up of pest population is, hence, likely in coconut gardens in which cassava is grown as an intercrop.

673. ANTONY, J.; DANIEL, MARIAMMA; KURIAN, CHANDY and PILLAI, G.B. 1979. Attempts on introduction and colonization of the exotic reduviid predator, *Platymeris laevicollis* Distant for the biological suppression of the coconut rhinoceros beetle *Oryctes rhinoceros*. L. In: Symposium on Plantation Crops, 2nd, Ootacamund, Jun. 26-29, 1979. Proceedings

of PLACROSYM II. Edited by C.S. Venkataram and others. p. 445-454. (CPCRI (RS), Kayangulam, Kerala).

Releases of the exotic predacious reduviid *Platyeris laevicollis* Distant at three places in India since 1968 for the biological control of *Oryctes rhinoceros* (L) on coconut are described. Although the predators killed many beetles, infestation tended to increase when releases ceased. Releases are being continued at one site in Karnataka.

674. BARTLETT, ALAN C. and RANANAVARE, H.D. 1983. Karyotype and Sperm of the Red Palm Weevil *Rhynchophorus ferrugineus* Fabr. (Coleoptera: Curculionidae). *Ann. Entomol. Soc. Amer.* 76(6):1011-1013. (Biology and Agric. Div., BARC, Trombay, Bombay, Maharashtra).

The red palm weevil, *Rhynchophorus ferrugineus* Fabr. a serious pest of coconut palm, *Cocos nucifera* L., in India and other coconut-producing countries, has a chromosomal formula of  $10A + XY_p$ . The karyotype of the red palm weevil consists of 22 metacentric chromosomes. Spermiogenesis was found in last-stage larvae, 2-week-old adults and 4-week-old adults. The sperm of the red palm weevil is also described.

675. BEENA, C.G. 1980. Mating and oviposition behaviour of *Trichospilus pupivora* Ferr. (Hym: Eulophidae). *J. Sci. Res.* 2(2):115-117. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

*Trichospilus pupivora* Ferr. is one of the important parasites of *Nephantis serinopa* Meyr., a serious caterpillar pest of coconut palms. In the present paper, behavioural aspects of courtship, mating and oviposition of *T. pupivora* are described. The courtship activities involved the characteristic movements of antennae, head and abdomen. Usually, mating occurs while the insect is within the host pupae. Oviposition takes place within two to four hour after

emergence. The females lay their eggs inside the host pupae by piercing the pupal skin with their ovipositor. More than one females are found to oviposit at a time on the same pupa.

676. CHANDRAN, E.R. and PRABHU, V.K.K. 1984. Localisation of the site of production of sex pheromone in female *Opisina arenosella* Walker (*Nephantis serinopa* Meyrick) (Lepidoptera: Cryptophasidae). In: Oriental Entomology Symposium, 3rd, Trivandrum, Feb, 21-24, 1984. Proceedings of symposium. p. 103-107. (Dept. of Zoology, Univ. of Kerala, Trivandrum, Kerala).

The male of *Opisina arenosella* Walker (*Nephantis serinopa* Meyr.) exhibits a series of behavioural responses preceding copulation: antennal waving, sudden flights, hopping, circling, wing expansion and wing vibration, of which all except antennal waving and sudden flights appear to be specific responses to olfactory cues contained in the female pheromone. The terminal abdominal segments are the sole source of female pheromone which can be better extracted in methylene chloride-methanol mixture (80:20 v/v) than in pure methylene chloride.

677. DESHPANDE, V.P.; DEVAIAH, M.C.; GOVINDAN, R.; THIPPESWAMY, C. and GOUD, R. RAJASHEKAR. 1982. Observation on coconut shot hole borer, *Xyleborus semiopacus* Eichhoff (Coleoptera: Scolytidae). *Curr. Res.* 10(7):114-115. (Dept. of Entomology, College of Agriculture, Dharwad, Karnataka).

Damage caused to coconut palms by *Xyleborus crassiusculus* (Motsch.) (*semiopacus* Eich.) in Karnataka is described. Bore holes were found at heights upto 140 cm. The trunks of infested palms shrank and infested palms had an average of 9.5 fronds, as compared with 19 on uninfested palms. Considerable numbers of the nuts on infested palms fell prematurely. When infested trunks were opened, severe tunnelling was found to a depth

of 18–22 cm and all stages in the life-history were present in the tunnels simultaneously.

678. GEETHA, P.R.; SANTHOSH BABU, P.B. and PRABHU, V.K.K. 1990. Endocrine control of development of male and female accessory sex organs in *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae). *Entomon* 15(1 & 2):107–111. (Dept. of Zoology, Univ. of Kerala, Trivandrum, Kerala).

Topically applied juvenile analogue S-methoprene did not stimulate growth of the male or the female accessory sex organs, while 20-hydroxyecdysone had a stimulatory effect on the male accessory organs though not on the female organs.

679. GEORGE, T.G. 1977. A study of the knowledge and attitude of farmers towards selected pest control measures for coconut. *Agric. Res. J. Kerala* 15(2):133–136. (CPCRI (RS), Kayangulam, Kerala).

A survey was conducted in Perinad village in Quilon district of Kerala, India, to evaluate the knowledge and attitude of farmers concerning selected pest control measures against rhinoceros beetle (*Oryctes rhinoceros* L.), red palm weevil (*Rhynchophorus ferrugineus* (Fabr.)), leaf-eating caterpillar (*Nephantis serinopa* Meyr.) and root feeding cockchafer (*Leucopholis coneophora* Burm.) on coconut. Although all respondents knew of the first 2 pests, only 65.7% were aware of the recommendations for pest control. The attitude of farmers to control measures which was judged by their reaction to 10 statements on the subject, was generally regarded as being favourable.

680. GEORGE, T.G.; SAHASRANAMAN, K.N. and GEORGE, M.V. 1977. Note on natural parasitism of *Nephantis serinopa* Meyrick. *Curr. Res.* 6(2):27–28. (CPCRI (RS), Kayangulam, Kerala).

Changes in the parasitism of larvae and pupae of *Nephantis serinopa* Meyr. are de-

scribed from monthly samples on coconut at 3 places in coastal Kerala, India, in 1967–70. The rate of parasitism averaged 29.43%, and the parasites present included *Perisierola nephantidis* Mues. *Elasmus nephantidis* Rohw., *Brachymeria nephantidis* Gah., *Bracon brevicornis* Wesm. and *Trichospilus pupivora* Ferr. The results are discussed in relation to the numbers of parasites that would have to be released to achieve biological control of *N. serinopa*.

681. GHORPADE, K.D. 1977. A new species of *Pseudoscymnus* (Coleoptera: Coccinellidae) predacious on coconut scale in peninsular India. *J. Nat. Hist.* 11(4):465–469 (Dept. of Entomology, UAS, Bangalore, Karnataka).

A new species of *Pseudoscymnus* that was discovered preying on *Aspidiotus destructor* Sign. infesting the lower surface of the leaves of coconut palm in several localities of Karnataka and Andhra Pradesh in 1968–72, is described from the adults as *P. dwipakalpa* sp. n. This is the first record of the genus from India, a key is given to these species.

682. GHORPADE, K.D. 1979. On the association of some Coccinellidae (Coleoptera) with spider nests. *Curr. Res.* 8(6):105–106. (Dept. of Entomology, UAS, Bangalore, Karnataka).

Eleven species of coccinellids, all of which prey on *Aspidiotus destructor* Sign. or *Cerataphis palmae* (Ghesq.) or *Raoiella indica* Hirst, are reported from the silken nests of spiders on coconut trees around Bangalore, Karnataka, India.

683. GHOSH, S.M. and ABDURAHIMAN, U.C. 1984. Bioethology of *Meterideia hutsoni* (Nixon) (Hymenoptera: Braconidae) a parasite of *Opisina arenosella* Walker, the black headed caterpillar pest of coconut. *Entomon* 9(31):31–34. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

*Meterideia hutsoni* (Nixon), which is a

recently recorded larval-pupal braconid parasite of *Opisina arenosella* Walk. has a distribution limited to certain areas of Malabar in Kerala. Observations on certain aspects of the biology and behaviour of this parasite are given. Females live longer than males with 50% honey, females lived for 12.4 days whereas males live for 9.3 days. In the field males outnumber females, their ratio being 4:3. Total duration of life stages from egg to adult varies from 17 to 23 days.

684. GHOSH, S.M. and ABDURAHIMAN, U.C. 1985. Bioethology and evaluation of comparative efficiency of *Apanteles taragamae*, a larval parasitoid of the coconut caterpillar, *Opisina arenosella*. *Philipp. J. Cocon. Studies* 10(2):4-8. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Investigations carried out in Thikkodi (Kerala) have shown that *Apanteles taragamae* is an efficient biocontrol agent of *Opisina arenosella*. The mean percentage of its parasitism on *O. arenosella* in the study area for 1983-84 is eight. Field data on the rate of parasitism indicates its promising potentiality as a biocontrol agent of the pest. The efficiency of this parasitoid is assessed in comparison to the other larval parasitoids of *O. arenosella*.

685. GHOSH, S.M. and ABDURAHIMAN, U.C. 1985. On some hyperparasitoids of *Opisina arenosella* the black headed caterpillar pest of coconut in Malabar, India. *Cocos* 3:29-31. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Over half the cocoons of the parasitoid *Apanteles taragamae* were parasitised by the hyperparasites, with *Aphanogmus manilae* accounting for 27.14% followed by *Meteoridea hutsoni* (17.4%), *Eurytoma albotibialis* (1.42%). *Pediobius imbreus* also caused 29.8% parasitism on *Bracon brevicornis*. Brief description of the biology of some of the hyperparasites are also

given.

686. GHOSH, S.M. and ABDURAHIMAN, U.C. 1985. Record of two new hyperparasites of *Apanteles taragamae* Vier. (Braconidae: Hymenoptera) a larval parasite of the black headed caterpillar pest of coconut. *Curr. Sci.* 54(6):295-296. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Some parasites which attack the serious pest *Nephantis serinopa* (*Opisina arenosella*) in turn serve as a host to some hyper-parasites reducing the efficiency of biological control. Four such hyperparasites were recorded in India.

687. GHOSH, S.M. and ABDURAHIMAN, U.C. 1987. A comparative study on the efficacy of entomophagous insects associated with the coconut caterpillar, *Opisina arenosella* Walker. In: *Advances in Biological Control Research in India*. Edited by K.J. Joseph and U.C. Abdurahiman. p. 92-101. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

*Opisina arenosella* is attacked by more than 29 parasites and 10 predators. Among the larval parasites, *Apanteles taragamae* outstands in field population. However, its efficacy is seriously impaired by the activity of several hyperparasites. *Goniozus nephantidis* and *Elasmus nephantidis* occur only in very low proportions in Malabar. *Meteoridea hutsoni* is restricted to certain regions of Malabar, where its percentage is surprisingly high. Among pupal parasites, *Trichospilus pupivora* *Brachymeria nephantidis* and *B. nosatoi* show a fluctuating rate, while all other chalcid parasites exhibit a very low rate.

688. GHOSH, S.M. and ABDURAHIMAN, U.C. 1988. Biology and reproduction of *Apanteles taragamae* Wilkinson (Hym. Braconidae) a larval parasitoid of *Opisina arenosella* Walker, the caterpillar pest of coconut. *Entomon.* 13(2):147-155. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

The female of *Apanteles taragamae* lays maximum number of eggs on the second day of its emergence. For oviposition the parasitoid prefers the host larvae confined within their own galleries. The second instar is preferred best and the frass left by them acts as a strong attractant to the female parasitoid. The male-female ratio varied from 1:1 to 2:3. The shortest duration required by the parasitoid to complete the development has been found to be 15 days.

689. GHOSH, S.M. and ABDURAHIMAN, U.C. 1988. On the biology of *Pediobius imbreus* (Hymenoptera: Eulophidae), a hyperparasite of *Opisina arenosella*, the black-headed caterpillar of coconut. *Cocos* 6:27-30. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

*Pediobius imbreus*, a hyperparasite of *Opisina arenosella*, is distributed throughout Kerala. The biology of this hyperparasite was studied in the laboratory. The mating took on an average 43 sec. The female started to lay eggs on the same day of emergence and laid upto 30 eggs in her life time. The eggs hatch after 36 to 40 h of incubation. There were three larval stages and the duration of immature stages from egg to adult emergence was completed in 412 to 420 h, and was dependent on temperature.

690. GHOSH, S.M. and ABDURAHIMAN, U.C. 1988. Some hyperparasitoids of *Opisina arenosella* Walker, the black-headed caterpillar pest of coconut. *Philipp. J. Cocon. Studies* 13(2):11-17. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

The parasitoid complex of *Opisina arenosella* showed the occurrence of many potential hyperparasitoids attacking the different stages of the primary parasitoids. Among them are *Pediobius imbreus*, *Aphanogmus manilae*, *Eurytoma braconidis*, *E. albotibialis*, *Brachymeria nephantidis*, *Meteoridea hutsoni* and *Elasmus nephantidis*, which have been found to parasitise the primary braconid parasitoids. The paper

gives a brief account of the biology of these hyperparasitoids and evaluates their role in reducing the population of the primary parasitoids.

691. GIRIJAKUMARI, S.; SANTHOSH BABU, P.B. and PRABHU, V.K.K. 1990. Endocrine glands in the last instar larvae of *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae). *Entomon.* 15(1-2):103-106. (Dept. of Zoology, Univ. of Kerala, Trivandrum, Kerala).

The final (eighth) instar larva of the black-headed caterpillar of coconut palm, *Opisina arenosella* Walker has two groups of median pars intercerebralis neurosecretory cells ( $M_1$  and  $M_2$ ) and two groups of lateral neurosecretory cells ( $L_1$  and  $L_2$ ) in the brain, on each side.  $M_1$ , the major group, consists of A (larger and smaller), B and C cells. The other groups consist of two A-cells each, in each half of the brain. The corpus cardiacum and the corpus allatum of each side form a single complex. Each prothoracic gland is made up of a maximum of 30 cells, and is innervated by five nerves; two from suboesophageal, two from prothoracic and one from mesothoracic ganglia.

692. GOPINADHAN, P.B.; MOHANDAS, N. and VASUDEVAN NAIR, K.P. 1990. Cytoplasmic polyhedrosis virus infecting red palm weevil of coconut. *Curr. Sci.* 59(11):577-580. (Dept. of Entomology, College of Agric., KAU, Trivandrum, Kerala).

A highly potent cytoplasmic polyhedrosis virus (CPV) has been detected for the first time in Kerala in stages of the red palm weevil, *Rhynchophorus ferrugineus* F., which infests coconut. It infects all the life stages of the pest, including the adult. Infection in the late grub stage resulted in malformed adults and suppressed the insect population drastically. The midgut of infected insects was enlarged and filled with thousands of polyhedral inclusion bodies (PIBs) visible under a light microscope.

Electron microscopic studies revealed surface projections of viral bodies characteristic of CPV.

693. JALALUDDIN, M. and MOHANASUNDARAM, M. 1989. Biological studies on *Aspidiotus destructor* Sign., a pest of coconut in Tamil Nadu. *Indian Cocon. J.* 19(11):14-19. (Dept. of Agric. Entomology, TNAU, Coimbatore, T.N.)

The biology of coconut scale (*A. destructor* Sign.) was studied in pot culture on tall and dwarf coconut types. For both sexes the incubation period of the egg was 8-9 days. The females had two moulting stages while the males usually had three with a total life cycle of 34 days for the females and 29 days for males. On the dwarf coconut the insects were smaller, which had longer life cycles and higher mortality (39.11%) than on the tall coconut types (28.44%). Under laboratory conditions on pumpkin a total life cycle of 32.2 days for the female and 27.5 days for the male was observed.

694. JALALUDDIN, M. and MOHANASUNDARAM, M. 1989. Control of the coconut scale *Aspidiotus destructor* Sign. in the nursery. *Entomon* 14(3-4):203-206. (Dept. of Agric. Entomology, TNAU, Coimbatore, T.N.).

Monocrotophos (0.04%), dimethoate (0.03%), methomyl (0.025%), methyl-O-demeton (0.025%), malathion (0.1%), methyl parathion (0.05%), phosphamidon (0.05%) and fish oil rosin soap were tested for the control of the diaspidid *Aspidiotus destructor* in a coconut nursery in Tamil Nadu, India. Three sprays with 2.5% soap or 4 sprays with methomyl, dimethoate, 1.25% soap or monocrotophos, at weekly intervals, gave 100% mortality of the pest, 6 days after the last spray.

695. JALALUDDIN, M. and MOHANASUNDARAM, M. 1989. Residual

toxicity of four insecticides recommended for control of coconut coccids on the parasitoid fauna of *Opisina arenosella* Wlk. *Entomon* 14(3&4):199-201. (Dept. of Agric. Entomology, TNAU, Coimbatore, T.N.).

Among the chemicals tested, fish oil rosin soap was found to be least toxic and its toxicity persisted for 1 day for *Trichospilus pupivora*, 6 days for *Tetrastichus israeli*, and 2 days for *Eriborus trochanteratus* and *Bracon hebetor* respectively. Methomyl was toxic upto 7-13 days, dimethoate for 9-14 days and methylparathion was found to be highly toxic to the parasitic fauna of *Opisina arenosella*.

696. JALALUDDIN, M. and MOHANASUNDARAM, M. 1989. Seasonal abundance of coconut scale *Aspidiotus destructor* Sign. and its natural enemies in Tamil Nadu, India. *Indian Cocon. J.* 20(3):12-17. (Dept. of Agric. Entomology, TNAU, Coimbatore, T.N.).

The scale insect population has a significant correlation with maximum temperature, sunshine hours and negatively correlated with morning relative humidity. Two aphelinid parasites viz. *Aphytis chrysomaphali* Marcat and *Cauca parvipennis* Gahn. were collected from field collections and they were active mostly in the months of May and July. Three predators are also reported to be active.

697. JALALUDDIN, M. and MOHANASUNDARAM, M. 1990. Efficacy of insecticides against coconut aphid *Cerataphis variabilis* in the nursery. *Indian Cocon. J.* 21(7-8):16-17 (Dept. of Entomology, TNAU, Coimbatore, T.N.).

The toxicity of four insecticides to *Cerataphis variabilis* on coconut nursery was determined in field test in Tamil Nadu. As judged by the number of live aphids after 5 days of spraying dimethoate (0.03%) and methomyl (0.025%) gave significantly better

control than other treatments.

698. JAYANTH, K.P. and NAGARKATTI, SUDHA 1981. Feasibility of rearing *Nephantis serinopa* Meyr. (Lepidoptera: Cryptophasidae) on an artificial diet. *J. Entom. Res.* 5(2):173-174. (National Centre for Biological Control, IIHR, Bangalore, Karnataka).

An artificial diet is described for the laboratory rearing of *Nephantis serinopa* Meyr., a major pest of coconut in India. This modified artificial diet involved the addition of casein, salt mixture no. 2, vitamin E, cholesterol and coconut leaf powder. Average duration of larval and pupal periods were 31.88 and 9.24 days respectively. Adults were normal and fertile. Each female moth laid 60 eggs.

699. JAYANTH, K.P. and NAGARKATTI, SUDHA 1984. Testing *Bessa remota* (Diptera: Tachinidae) against *Opisina arenosella* (Lepidoptera: Cryptophasidae) and other Lepidopterous host in India. *Entomophaga* 29(4):415-419. (IIHR, Bangalore, Karnataka).

*Bessa remota* (Ald) was introduced from Malaysia for trials against *Opisina arenosella* Wlk, an important pest of coconut in India. Its development was studied on *O. arenosella* reared on artificial diet. Eggs were laid readily on half to full grown larvae. Incubation, larval and pupal periods were 2.18, 6.69 and 9.34 days respectively at 25±2°C and 60-80% R.H. Females lived for 23 days producing 108.29 eggs on an average, of which 53.10% yielded puparia. Among eight other lepidopterous hosts tested 4 to 20% parasitism was observed on *Crociodolomis binotalis* (Z), *Spodoptera litura* (Fb.), *Sylepta derogata* Fb, and *Trichoplusia ni* Hb.

700. JAYAPRAKASH, R. and PRABHU, V.K.K. 1986. Forked sensillum on the antenna of *Opisina arenosella* Walker (Lepidoptera: Cryptophasidae). *Entomon* 11(2):127-128. (Dept. of Zoology, Univ. of Kerala, Trivandrum,

Kerala).

Scanning electron microscopic studies on the antenna of the black-headed coconut caterpillar, *Opisina arenosella* revealed that, in addition to the five types of sensilla noted under light microscope, basiconic sensillum appeared sometimes forked.

701. JAYARAJ, S., ed. 1985. Integrated pest and disease management; proceedings of the national seminar, Coimbatore: Tamil Nadu Agricultural University. 433 p. (Centre for Plant Protection Studies, TNAU, Coimbatore, T.N.).

Incorporates about 50 papers. Included are contributions relating to the integrated control of pests and diseases of rice, sugarcane, coconut, vegetables, tobacco and fruits; pests of cotton; diseases of pepper, rubber, betel vine and seeds, together with papers of a more general nature including those on the role of rhizosphere and phyllosphere microflora, insect pests, the use of entomopathogens, monitoring and surveillance of pests and diseases and the transfer of plant protection technology.

702. JAYARAJ, S. 1989. Studies on the integrated management of coconut black-headed caterpillar, *Opisina arenosella* in Tamil Nadu. *J. Plantn Crops* 16(Suppl.):171. (Centre for Plant Protection Studies, TNAU, Coimbatore, T.N.).

The role of *Bracon brevicornis*, *Parasierola nephantidis* (*Goniozus nephantidis*) and *Trichospilus pupivora* in reducing populations of the coconut pest *Opisina arenosella* was investigated in the field in Tamil Nadu, India. *G. nephantidis* was the most effective of the three parasitoids, and it was found that the number of progeny per female of this species could be increased markedly by treatment with Altosid (methoprene). Since not all of the parasitoids were effective against *O. arenosella*, a single trunk application of systemic insecticide was necessary to control the pest. Attempts were made to rear the parasitoid *Tetrastichus*

*israelensis* in the laboratory for field release.

703. JAYARAMAN, V. 1985. Study on repellent action of phorate against rhinoceros beetle, *Oryctes rhinoceros* Linn. In: Behavioural and physiological approaches in pest management. Edited by A. Raghupathy and S. Jayaraj. Coimbatore: Tamil Nadu Agricultural University. p. 116-119. (Dept. of Agric. Entomology, TNAU, Coimbatore, T.N.).

The effectiveness of application of 1:1 mixtures of sand and the granules of four different insecticides at various rates to both sides of the crown region or the first leaf axil of coconut palms for the control of *Oryctes rhinoceros* was determined in field tests in Tamil Nadu, in 1978. Comparison was made with treatment having 10% dust of HCH at 0.1 kg/palm. Treatment with 10% granules of phorate gave complete protection upto 60 days on 3-5 year old palms when applied at 5g/palm and on 1-2 year old seedlings when applied at 0.5 g/palm.

704. JEYRAJ, R.; THANGARAJ, T.; VASUKI, C.A. and ARUCHAMI, M. 1986. Characteristics of phenol oxidases in larval cuticle of the coconut pest *Oryctes rhinoceros*. *Proc. Ind. Acad. Sci. (Ani. Sci.)* 95(6):739-744. (Dept. of Zoology, Kongunaduray Sci. College, Coimbatore, T.N.).

Characteristics of cuticular phenoloxidases of the coconut pest, *Oryctes rhinoceros* were studied biochemically with respect to substrate specificity, pH optima, thermostability and the behaviour of the enzyme in the presence of various chemicals. Biochemical studies indicate that the larval cuticle contains tyrosinase (EC, 1.10.3.1. Ortho diphenol: O<sub>2</sub> oxido reductase), and laccase type of enzyme (FC, 1.10.3.2 Para diphenol: O<sub>2</sub> oxido reductase). These enzymes showed similarity to enzyme types A and C with respect to the enzyme activity in the larval cuticle of *Calliphora vicina*. In the electrophoretic study two fractions

are discernable in the gel which confirms the occurrence of two enzyme namely tyrosinase and laccase types.

705. JOHN, T. THOMAS. 1988. Control of mealy bugs in coconut gardens. *Indian Cocon. J.* 19(5):10. (Dist. Agric. Farm, Mavelikkara, Kerala).

The paper deals with the nature and extent of damage caused by mealy bugs on coconut. A control measure with 0.2% carbaryl spray is recommended at 2-3 weeks interval.

706. JOY, P.J. and JOSEPH, K.J. 1977. The advantages, disadvantages and the possibilities of the utilization of *Brachymeria* parasites for the biological control of *Nephantis serinopa*, the black-headed caterpillar pest of coconut. *Agr. Res. J. Kerala* 15(1):66-68. (College of Hort., KAU, Vellanikkara, Kerala).

This paper deals with the advantages and disadvantages of utilizing *Brachymeria* (*Neobrachymeria*) *nosatoi* and *B. nephantidis* as agents for the biological control of *Nephantis serinopa*.

707. JOY, P.J. and JOSEPH, K.J. 1977. Role of pupal parasites in the biological control of the black-headed caterpillar. *Indian Cocon. J.* 8(1):1-2. (College of Hort., KAU, Thrichur, Kerala).

*Nephantis serinopa* Meyr., the black-headed caterpillar pest of coconut in Kerala, is parasitised by a number of pupal parasites, of which the most important are: *Brachymeria* (*Neobrachymeria*) *nosatoi* Habu and *B. nephantidis* Ghan. Detailed studies have been undertaken on the distribution and percentage of parasitism of these and other parasites so as to study their role in the biological control of *N. serinopa*.

708. KANNAN, S. and PRABHU, V.K.K. 1985. Probable role of brain-neurosecretory cells in water balance in *Oryctes rhinoceros* (Coleoptera:

Scarabaeidae). *Entomon* 10(4):313-315. (Dept. of Zoology, Univ. of Kerala, Trivandrum, 695581, Kerala).

In the scarabaeid beetle *Oryctes rhinoceros*, most of the 'A' type neurosecretory cells of the brain appear to elaborate a diuretic principle which is stored in the corpus cardiacum. However, one pair of the 'A' cells among them lying close to the median line elaborate on antidiuretic principle.

709. KAPADIA, M.N. 1981. Susceptibility of three cultivated coconut varieties to *Nephantis serinopa* Meyr. *Indian Cocon. J.* 12(4):4-5. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

In an experiment conducted to determine the susceptibility and resistance of the three coconut varieties viz., WCT, T x D and DG to *Nephantis serinopa* it was observed that percentage of both leaf damage and leaflet damage was highest in WCT and lowest in DG. Leaflet characters was a factor that influenced pest damage. The study concluded that DG is comparatively tolerant to *N. serinopa* attack and WCT and T x D were susceptible and moderately susceptible, respectively. Hence DG variety can be exploited as one of the parents for breeding varieties resistant to the pest.

710. KAPADIA, M.N. 1982. Further record of host plant of *Nephantis serinopa* Meyrick in Gujarat. *Indian Cocon. J.* 12(12):1. (Dept. of Entomology, College of Agric., GAU, Junagad, Gujarat).

*Nephantis serinopa* has been observed to feed on fish tail palm, *Caryota* sp. Biology studies were carried out using this host.

711. KAPADIA, M.N. 1982. Note on laboratory evaluation of some insecticides against the coconut leaf eating caterpillar *Nephantis serinopa* Meyr. *Indian Cocon. J.* 13(3):10-20. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

Since DDT is harmful to parasites and predators of *Nephantis serinopa* Meyr. trials were carried out to select a suitable insecticide. DDT 0.2%, carbaryl 0.2%, BHC 0.2%, quinalphos 0.05%, methyl parathion 0.05%, endosulphan 0.07% and monocrotophos 0.05% were sprayed at the rate of 6 l/10 year old palm and the results were recorded in each case. All these insecticides proved to be effective but only BHC, methyl parathion and monocrotophos were recommended due to their reduced toxicity to useful insects.

712. KAPADIA, M.N. 1983. New host record of *Brachymeria excarinata* Gahan (Chalcididae: Hymenoptera) in Mahuva. *Indian Cocon. J.* 14(2):6. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

*Brachymeria excarinata* a pupal parasite of *Nephantis serinopa* has been for the first time identified parasitising another unidentified slug-caterpillar in Gujarat State.

713. KAPADIA, M.N. 1983. Record of a new pupal parasite of *Nephantis serinopa* Meyr. in Gujarat. *Indian Cocon. J.* 13(11):5. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

An ichneumonid parasite *Echthromorpha agrestona* Swederus is found parasitising the *Nephantis* pupae at the plantation crops research station, Mahuva. The activity of this parasite was observed during the winter. The adult parasite resembles the *Xanthopimpla* adult except in size and some coloured marking. The size of *Echthromorpha* adult was bigger than that of *Xanthopimpla* adult. The wing venation and abdominal dorsums of this parasite were dark in colour.

714. KAPADIA, M.N. 1983. Record of *Pediobius* sp. hyperparasite of *Perisierola nephantidis*, M. and *Bracon brevicornis* W. in Gujarat. *Indian Cocon. J.* 14(5):7. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

*Perisierola nephantidis* M. and *Bracon brevicornis* W. are the effective larval parasites of coconut leaf eating caterpillar, *Nephantis serinopa* Meyr. in Mahuva area of Gujarat state. The cocoons of both larval parasites collected from the coconut field are found to be parasitized by two species of *Pediobius* identified as *brunchicida* (Ronadami) and *imbreus* (Walker).

715. KAPADIA, M.N. 1984. New records of coconut scale insects and their enemies in Gujarat. *Indian Cocon. J.* 14(11):9-10. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

The article records five new species of scale insects found in Gujarat. Characters of scale, intensity of damage, variety and part of palm affected and the parasites/predators recommended for the biological control with respect to each of these species are discussed.

716. KAPADIA, M.N. 1985. Occurrence of *Stephanitis typicus* Distant (Tingidae: Heteroptera) on coconut in Mahuva. *Indian Cocon. J.* 15(11):13-14. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

A brief note on lace bug *S. typicus* is presented. *S. typicus* has been reported to be a vector for pathogen, probably a sap transmissible organism associated with root (wilt) of coconut.

717. KAPADIA, M.N. 1987. Biology of *Cardiastethus* sp. nr. *nazareus* Reuter (Hemiptera: Anthocoridae), a predator of *Opisina arenosella* Walk. *Gujarat Agric. Univ. Res. J.* 12(2):55-56. (Plantation Crops Res. Station., GAU, Mahuva, Gujarat).

The biology of a species of *Cardiastethus* near *C. nazareus*, a predator of the xyloryctid coconut pest *Opisina arenosella* in Gujarat, India, was studied in the laboratory in 1981. First-instar larvae of *Corcyra cephalonica* were provided as food. The incubation period was

2-5 days, with an average of 3.42. The five nymphal instars averaged 4.25, 2.5, 2, 2.38 and 4.38 days, respectively. The total nymphal period averaged 15.63 days. Each female laid 8-23 eggs, with an average of 14.33.

718. KAPADIA, M.N. 1987. Occurrence and distribution of different parasites of *Opisina arenosella* Walker under Mahuva conditions of Gujarat. *Gujarat Agric. Univ. Res. J.* 12(2):17-21. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

Studies on the natural enemies of the xyloryctid coconut pest *Opisina arenosella* were carried out in Gujarat, during 1980-83. The maximum parasitism by the larval parasitoids *Bracon brevicornis* (5.73%) and *Parasierola nephantidis* (*Goniozus nephantidis*) (5.98%) was recorded in Dec. 1982 and November, 1981, respectively. Both parasitoids were more active during the cold months than during the warm and humid times of year.

Larval mortality due to unidentified diseases was highest in June 1981 (24%). The highest parasitism by the pupal parasitoids *Brachymeria* spp. (26.43%) and *Xanthopimpla punctata* (10.22%) was recorded in February, and August 1981, respectively. *Brachymeria* spp. were active throughout the year, while *X. punctata* was not active in February-March, May or July. Total parasitism was highest (24.9%) in February, followed by June (20.83%), and lowest (1.04%) in May.

719. KAPADIA, M.N. and MITTAL, V.P. 1986. Biology of *Parasierola nephantidis* Muesebeck and its importance in the control of *Opisina arenosella* Walker under Mahuva (Gujarat State) conditions. *Gujarat Agric. Univ. Res. J.* 12(1):29-34. (Dept. of Entomology, GAU, Junagadh Campus, Junagadh, Gujarat).

The biology of *Parasierola nephantidis* (*Goniozus nephantidis*), a parasite of the coconut pest *Opisina arenosella*, was studied in

the laboratory and periodical observations were carried out on the extent of parasitism in the field in Gujarat, in 1982-84. In the field, the parasite was active throughout the year except in May, August and November. Low parasitism was observed during the humid months. Average parasitism was highest in January (4.12%) and February (6.12%). Hyperparasitism of *G. nephantidis* by the eulophid *Pediobius imbreus* was from 31.82% to 90.14%.

**720. KAPADIA, M.N. and VALIA, R.Z. 1986.** A note on the biology of *Oryctes rhinoceros* L. as a pest of coconut palm. *Gujarat Agric. Univ. Res. J.* 12(1):53-55. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

The paper includes details on the biology of *O. rhinoceros* under Gujarat conditions. During a field survey on the larval population of the pest, as many as 15,850 grubs were observed in 19,683 manure pits with a total volume of 19,883 m<sup>3</sup>.

**721. KAREEM, A. ABDUL; SADAKATHULLA, S. and SUBRAMANIAM, T.R. 1974.** Antifeeding effects of neem seed extracts against larvae of *Euproctis fraterna* M. (Lymantriidae : Lepidoptera) on castor and *Nephantis serinopa* Meyr. (Cryptophasidae : Lepidoptera) on coconut. *Andhra Agric. J.* 21(3&4):99-101. (TNAU, Veppankulam, T. N.).

The efficacy of neem seed with rind, kernel alone and rind alone at 1%, 0.5% and 0.25% on both the species was evaluated. The potential inhibition of feeding of both the larvae species affording maximum feeding protection of more than 75% in kernel extract was recorded.

**722. KASHYAP, R.K.; VERMA, A.N. and BHANOT, J.P. 1984.** Termites of plantation crops and their damage and control; review article. *J. Plantn Crops* 12(1):1-10 (Dept. of Entomology, HAU, Hissar, Haryana).

The termite infestation on coconut is more common in nurseries. Germinating nuts

and transplanted seedlings are frequently attacked. Various termite species attacking coconut palm have been tabulated and their harmful effect on yield and control measures were reviewed.

**723. KURIAN, CHANDY 1977.** Modern trends in biological control of pests. *Cocon. Bull.* 7(11):1-4. (CPCRI (RS), Kayangulam, Kerala).

Role of biological control in pest management and its scope, success stories in biological control of pests, the sophisticated methods like sterile male release, cytoplasmic incompatibility, chromosomal transformation etc. have been discussed. The utility of a few of the above methods in the management of coconut pests has been explained.

**724. KURIAN, CHANDY and ABRAHAM, V.A. 1984.** Integrated pest management of coconut gardens. *Indian Cocon. J.* 15(3 & 4): 27-32. (CPCRI (RS), Kayangulam, Kerala).

The number of recorded pests of coconut is alarmingly great. They are mostly coleopterans, lepidopterans and hemipterans found almost in all parts of the palm. In addition mammalian pests like rats, bats, squirrels, porcupines and avian pests like woodpecker and Indian hoopy are recorded. The assessment of damage caused by each pest, knowledge of its economic distribution, biology and seasonal abundance are essential pre-requisites for evolving effective control measures against them. A brief review of the important results of the work done in India on management of the major pests is discussed.

**725. KURIAN, CHANDY; ABRAHAM, V.A. and KOYA, K.M. ABDULLA. 1979.** Studies on *Paradasynus rostratus* Dist. (Heteroptera: Coreidae), a pest of coconut. In: Symposium on Plantation Crops, 2nd, Ootacamund, Jun. 26-29, 1979. Proceedings of PLACROSYM II. Edited by C.S. Venkataram and others. p. 484-503. (CPCRI (RS), Kayangulam, Kerala).

*Paradasynus rostratus* Dist. a coreid bug was recently recorded as a new pest of coconut in India. The nymphs and adults feed on the tender nuts causing immature nut fall and malformation. There are five nymphal instars and the total life period is 82–97 days. The description of various stages, life history, nature and extent of damage and the distribution of the pest in space and time are discussed.

726. KURIAN, CHANDY; ABRAHAM, V.A. and PONNAMMA, K.N. 1984. Attractants, an aid in red palm weevil management. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15–18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p. 581-585. (CPCRI (RS), Kayangulam, Kerala).

The red palm weevil (*Rhynchophorus ferrugineus* F.), is an enemy of young coconut palms. Traps and attractants, by which adults can be trapped and killed have been proved to be effective components of integrated pest management. Log traps consisting of tender coconut stems, 50 cm long and split longitudinally were found to be superior to metal traps. The cut surfaces were treated with candidate attractants. Out of sixteen combinations tested in the field, logs treated with coconut toddy+yeast+acetic acid were the best, followed by coconut toddy+acetic acid, pineapple+molasses+yeast, pineapple+molasses and molasses+yeast. The use of coconut log traps treated with the above combination is recommended as one of the effective components of integrated pest management.

727. KURIAN, CHANDY; ABRAHAM, V.A.; PONNAMMA, K.N. and KOYA, K.M. ABDULLA. 1978. *Myllocerus curvicornis* (F.) a new pest of coconut. *J. Plantn Crops* 6(1):44–45. (CPCRI (RS), Kayangulam, Kerala).

Damage caused by *Myllocerus curvicornis* (Coleoptera: Curculionidae) has been described. The adult weevils remain in the lower surface of the leaflets, concentrating more towards the

tip region and feed from the margin in circular patches making feeding scars, which turn into necrotic patches. This lead to bending and drying of leaflets. The infestation is mostly confined to the middle and inner whorls except for the spear and 2–3 inner most leaves. A field study indicated 30% infested palms with 14% of the leaves attacked.

728. KURIAN, CHANDY; PILLAI, G.B.; ANTONY, J.; ABRAHAM, V.A. and NATARAJAN, P. 1983. Biological control of insect pests of coconut. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27–31, 1976. Edited by N.M. Nayar. New Delhi: Wiley Eastern. p. 361-375. (CPCRI (RS), Kayangulam, Kerala).

*Oryctes rhinoceros* L., *Nephantis serinopa* M., *Rhynchophorus ferrugineus* F. and *Leucopholis coneophora* B. are the major pests of coconut in India. These insects are attacked by a number of parasites, predators and microorganisms including nematodes. The most important biological control agents for the control of the black beetle are the indigenous predators *Santalus parallelus* P. and *Agrypnus* (near *bifoveatus* C) and the exotic reduviid bug *Platymeris laevicollis* G. The pathogens *Metarrhizium anisopliae* (M.), *Rhabdionvirus oryctes* and a nematode *Neoaplectana carpocapsae* (DD-136) also show promise. The establishment of the above agents depends very much on the ecological conditions and biotic factors.

No biological agent other than *Chelisoche moris* F. has been reported on red palm weevil in India. The scope of utilizing parasites, predators and pathogens for the control of the cockchafer is also discussed. The leaf eating slug caterpillars *Contheyla rotunda* H., *Macroleptra nararia* M. and *Parasa lepida* C. are attacked by bacterial and fungal pathogens and insect parasites. *Stephanitis typicus* D., the suspected vector of the root (wilt) disease of

coconut, has a predator, *stethoconus praefectus* D.

Mention is made also of parasites obtained on these pests from other countries.

**729. LOUIS, I. HENRY and CHANDRASEKHARAN, N.R.** 1980. A note on the Weevil *Diocalandra stigmaticollis* as a pest of coconut palm in Tamil Nadu. *Indian Cocon. J.* 11(11):5-6. (TNAU Sub-centre, Veppankulam, T.N.).

A species of *Diocalandra* has been found as a pest in the coconut gardens of Kanyakumari, Tinneveli, Tanjore and Coimbatore districts affecting the bark of the young and grown up palms. The adult weevil is dark brown in colour. It has a long, pointed snout with a gentle inward curve. It is about 6 mm in length, and 1.5 mm in width. The larva is dull white in colour, about 8 mm in length having a wrinkled and curved body without legs. Posterior half of the abdomen is well developed. The larvae of the weevil burrow into the soft tissues of the bark and never found deep in the fibrous portion of the stem. The cylindrical cavities of the adult weevils are filled with resinous secretions, similar to thick molasses. The symptom of the attack is very often mistaken for early stages of stem bleeding. In the affected palm the production of leaf and spathe is delayed. The buttons shed considerably and setting affected upto 75%. The yield of the palm is affected completely and the palm succumbs to the attack in two to three years.

**730. MANJUNATH, T.M.** 1985. Coconut black headed caterpillar on banana and coconut. *FAO Plant. Prot. Bull.* 33(2):71-72. (Biocontrol Res. Laboratory, Rabindranath Tagore Nagar, Bangalore, Karnataka).

Severe outbreaks of *Opisina arenosella* on coconut occurred in several parts of Karnataka and Andhra Pradesh, in 1983-84. Observations made in Guntur district, AP, showed that larvae

fed on leaves and the green matter of husks, causing premature nut drying and thereby reducing the yield of copra. Infestation of the pest also occurred on the leaves of banana either intercropped with coconut or grown as a monocrop; the damage caused was similar to that of coconut leaves. This is the first record of the pest attacking banana. The parasites *Apantelus taragamae* and *Parasierola nephantidis* (*Goniozus nephantidis*) were reared from *O. arenosella* larvae from both coconut and banana. The parasitism rates of the two species reached 5 and 28% respectively. The use of these parasites in the control of the pest is discussed.

**731. MATHEN, K. and KURIAN, CHANDY.** 1980. Biology and bionomics of *Stephanitis typica* (Distant). *Proc. Indian Acad. Sci. B* 46(6): 832-836. (CPCRI, (RS), Kayangulam, Kerala).

Direct and indirect evidences are available on *Stephanitis typica* (Distant) (Tingidae) transmitting coconut root (wilt) disease in Kerala, responsible for an annual loss in yield of 34 crore nuts. The lace bug, originally recorded from banana is polyphagous. On coconut foliage, the bug completes its life cycle in about 25 days with an average incubation period of twelve days and a total nymphal period of thirteen days covered under five instars. Both the imago and nymphs drain the contents of the mesophyll tissue. There are two peak periods of abundance in March-May and September-October. Fluctuations in populations are directly correlated to temperature and sunshine, inversely proportional to relative humidity and rainfall. On individual palms population increases from outer to the inner leaves. On each leaf, they occur in greater numbers in middle leaflets. Diseased palms harbour more insects than the healthy. The insect is preyed upon by a mirid bug. The pest is easily controlled by spraying carbaryl.

**732. MATHEN, K.; RADHAKRISHNAN NAIR, C.P.; GUNASEKARAN, M.; GOVINDANKUTTY,**

M.P. and SOLOMON, J.J. 1988. Stylet course of lace bug *Stephanitis typica* (Distant) in coconut leaf. *Proc. Indian Acad. Sci. (Animal Sci.)* 97(6):539-544. (CPCRI (RS), Kayangulam, Kerala).

The stylet course of the tingid *Stephanitis typica* in coconut leaves was studied in the laboratory, using insects collected from the field in India. The stylets were inserted through stomata, rupturing the walls of cells traversed to reach the vascular bundles. The stylet tip terminated in the phloem, suggesting that this species could acquire phloem-bound mycoplasma-like organisms associated with coconut root (wilt) in India.

733. MATHEN, K.; RAJAN, P. and RADHAKRISHNAN NAIR, C.P. 1987. Description of the salivary gland of the lace bug *Stephanitis typicus* (Dist.) *Indian Cocon. J.* 17(9):3-4. (CPCRI (RS), Kayangulam, Kerala).

Structural details of the salivary gland of the lace bug, dissected with the help of a stereomicroscope are given. Details are also illustrated through diagrammatic and photographic aids.

734. MATHEW, K.P.; NAIR, M.R.G.K. and ABRAHAM, C.C. 1979. Toxicity of newer insecticides to coconut caterpillar *Nephantis serinopa* Meyr. and its parasite *Bracon brevicornis* Wesmeal. *Agric. Res. J. Kerala* 16(2):188-192. (CPCRI (RS), Kayangulam, Kerala).

Phosalone was the most (highly) toxic insecticide against *N. serinopa* and *B. brevicornis*, with an LD<sub>50</sub> value of 0.02428, followed by endosulfan, malathion and quinalphos, with LD<sub>50</sub> values of 0.02428, 0.05288 and 0.056614, respectively. Fenthion, phosphamidon, monocrotophos, fenitrothion DDVP, BHC and carbaryl were much less toxic and were not useful for controlling the caterpillar pest. All the insecticides except phosalone, quinalphos, monocrotophos, carbaryl and BHC showed

negligible residual toxicity by the eighth day of insecticidal application; on the 16th day none of the insecticides except carbaryl and monocrotophos had any residual toxicity to the larvae and the residues of monocrotophos and carbaryl still had substantial toxicity.

735. MATHUR, P.N.; SAMATHANAM, G.J. and SINGH, ABHIRAJ. 1984. Coconut leaf miner beetle (*Promecotheca cumingi* Baly). *Plant. Prot. Bull. India* 36(2/3): 91-93. (Plant Quarantine & Fumigation Station, Madras, T.N.).

Details are given of the geographical distribution, morphology, biology, economic importance and the importance of quarantine measures to prevent its introduction to India.

736. MINI, A. and PRABHU, V.K.K. 1986. Significance of critical developmental stage on starvation induced endocrine mediated precocious metamorphosis in *Oryctes rhinoceros* (Coleoptera: Scarabaeidae). *Proc. Indian Acad. Sci. (Ani. Sci.)*. 95(4):379-385. (Dept. of Zoology, Univ. of Kerala, Trivandrum, Kerala).

Final instar larvae of *Oryctes rhinoceros*, collected from coconut palms in Kerala, underwent precocious metamorphosis when subjected to starvation and the resulting adults were subnormal in size. However, the larvae showed this kind of response to starvation only after attaining a certain critical stage of development, other-wise they died after surviving for a varying period depending on their age. Topical applications of 50 µg of the growth regulator kinoprene on five alternate days from the fifth day of starvation caused a significant delay in the onset of precocious metamorphosis suggesting an endocrine involvement. It is suggested that starvation causes decrease in juvenile hormone titre which triggers a chain of events leading to precocious metamorphosis.

737. MOHAMED, U.V.K.; ABDURAHIMAN, U.C. and REMADEVI, O.K. 1982. Coconut caterpillar

and its natural enemies. Zoological Monograph no. 2. Calicut: Dept. of Zoology, Univ. of Calicut. 162p. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

This monograph gives a comprehensive account of the studies made so far on the parasites and predators associated with the coconut caterpillar, *Opisina arenosella*. In the part I, the authors have assessed the importance of the coconut palm and the damage caused by the pest to the tree. The life history of the pest is also given.

738. MOHAMED, U.V.K.; ABDURAHIMAN, U.C. and REMADEVI, O.K. 1982. Notes on two Carabid (Carabidae: Coleoptera) predators of *Nephantis serinopa* Meyrick (Xylorictidae: Lepidoptera) from Kerala. *Entomon* 7 (3):341-343. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Short descriptions of the life history, reproduction and predatory behaviour of two beetles, viz., *Parena nigrolineata* Chaud. and *Calleida splendidula* (F), which are predators on the coconut caterpillar, *Nephantis serinopa* Meyr. are given.

739. MOHAMED, U.V.K.; ABDURAHIMAN, U.C. and REMADEVI, O.K. 1983. Bio-ethology of *Brachymeria* (*Neobrachymeria*) *nosatoi* (Chalcididae: Hymenoptera) a pupal parasite of the coconut pest, *Nephantis serinopa* (Xylorictidae: Lepidoptera). *J. Sci. Res.* 5(3):147-151. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

*Brachymeria* (*Neobrachymeria*) *nosatoi* Habu is one of the pupal parasites of *Nephantis serinopa* Meyr. the caterpillar pest of coconut. Observations made on the life history, longevity and reproductive behaviour of this parasite are given. Only one larva per host survives even if more than one occur in their early stages. Host feeding increases the longevity of the adult females. The involvement of female-borne

chemical stimulus (pheromone) serving as a factor in the courtship behaviour suggested. For oviposition the female accepts the host pupae only when they are covered by silken cocoon and galleries.

740. MOHAN, K.S.; JAYAPAL, S.P. and PILLAI, G.B. 1983. Baculovirus disease in *Oryctes rhinoceros* population in Kerala. *J. Plantn Crops* 11(2):154-161. (CPCRI (RS), Kayangulam, Kerala).

A baculovirus disease was found in *Oryctes rhinoceros* beetles in Kerala. The symptoms conformed to those reported from South East Asia and the South Pacific Islands. The disease was diagnosed and confirmed by visual symptoms of midgut, smear of midgut contents, immuno-osmophoresis, bioassay in grubs and beetles and electron microscopy of midgut sections of the beetle. The smear test and immuno-osmophoresis were found to be ideal diagnostic methods for routine screening. The bacilliform baculovirus particles measured 215-260 x 77-198 nm.

741. MOHAN, K.S.; JAYAPAL, S.P. and PILLAI, G.B. 1985. Response of *O. rhinoceros* larvae to infection by *O. baculovirus*. *J. Plantn Crops* 13(2):116-124. (CPCRI (RS), Kayangulam, Kerala).

Three larval instars of *Oryctes rhinoceros* were infected with *O. baculovirus* through contaminated feed. The primary external pathological symptom was translucency of the throax. Internally, the midgut contained turbid fluid with flakes of sloughed-off epithelial tissue. Baculovirus infection in larvae could be diagnosed in Giemsa stained scrappings of the midgut epithelium two days after inoculation, whereas bioassay test could detect infection on the third day.

742. MOHAN, K.S.; JAYAPAL, S.P. and PILLAI, G.B. 1989. Biological suppression of coconut rhinoceros beetle *Oryctes rhynoceros* L. in

Minicoy, Lakshadweep by *Oryctes baculovirus*-impact on pest population and damage. *J. Plantn Crops* 16(Suppl.): 163-170. (CPCRI (RS), Kayangulam, Kerala).

The population of *Oryctes rhinoceros* (L), one of the key pests of coconut palm, has been substantially reduced in Minicoy island, Lakshadweep, through the use of a virus disease of the pest. *O. rhinoceros* beetles were infected with *Oryctes baculovirus* ( $\approx$  30LD<sub>50</sub> dose/ml. of inoculum) and released into the pest population in Minicoy Island in April, 1983. The virus was previously isolated from field-collected, diseased *O. rhinoceros* beetles from Kayangulam in Alleppey district, Kerala. Pre-release observations at Minicoy in April, 1983 revealed high incidence of pest damage to coconut and the absence of the viral disease in the pest population. Post-release observations recorded after two years revealed spread of the virus disease to the subsequent generations of beetles and larvae in breeding sites. The resultant epizootic in the pest population drastically reduced the larval population in breeding sites, leading to a substantial reduction in the damage to coconut palms in experimental plots.

743. MOHAN, K.S. and PILLAI, G.B. 1982. A selective medium for isolation of *Metarrhizium anisopliae* from cattle dung. *Trans. Br. Mycol. Soc.* 78(1):181-182. (CPCRI (RS), Kayangulam, Kerala).

The paper describes a selective medium for the isolation of *M. anisopliae* from cattle dung and farm yard organic debris. The constitution of the medium, the efficiency of the medium as evidenced in field tests and special use of the medium to study the spread of the pathogen in newer areas etc. have been discussed.

744. MOHAN, K.S. and PILLAI, G.B. 1983. Immuno-osmophoresis technique for quick

diagnosis of oryctes virus (Baculoviridae) of rhinoceros beetle, *Oryctes rhinoceros* L. *Indian. J. Exptl. Biol.* 21:470-471. (CPCRI (RS), Kayangulam, Kerala).

Immuno-osmophoresis method is suitable for quick screening of field collected rhinoceros beetles and grubs and to assess the intensity of natural incidence of baculovirus disease.

745. MURTHY, M. SATYANARAYANA. 1980. A new approach for the control of black headed caterpillar of coconut. *Agric. & Agro. Ind. J.* 13(7): 1.

Black headed caterpillar *Nephantis serinopa* is the major pest of coconuts in Andhra Pradesh. Although the pest is kept under control by adopting biological control measures, the climatic conditions, specially in summer do not promote this satisfactorily. Hence the other quick action methods like insecticidal control are inevitably needed. Author described an insecticidal application through the root of the palm.

746. MURTHY, V.T. SUNDARA. 1980. Effects of diflubenzuron on a field population of the coconut black headed caterpillar, *Nephantis serinopa* Meyrick (Lepidoptera) and its parasite, *Parasierola nephantidis* (Muesebeck) (Hymenoptera) in India. *Bull. Entomol. Res.* 70(1):25-31. (Res: Centre for Biological Control of Coconut Black Headed Caterpillar, TNAU, Vaniyambadi, T.N.).

Diflubenzuron was applied once at 2.5 - 20 g (a.i.) in 10 l of water to coconut palms infested with larvae of *Nephantis serinopa* Meyr. in Tamil Nadu, India. The entire field population of larvae was eliminated within 14-18 days, depending on the dose. Diflubenzuron apparently had an antifeedant effect on the larvae. The compound directly or indirectly affected the development of *Parasierola nephantidis* (Mues), a parasite of *N. serinopa*. The

preference of female parasites for parasitising host larvae got reduced. The number of progeny produced from a single host larvae treated with diflubenzuron in the field also got significantly reduced. Treatment of mature parasite larvae directly with diflubenzuron in the laboratory affected their development and caused morphological deformities in the adults.

747. MURTHY, V.T. SUNDARA and SANTHANAKRISHNAN, K. 1978. Utility of unmated females of *Perisierola nephantidis* Muesebeck in the biological control of *Nephantis serinopa* Meyrick. *Curr. Sci.* 47(23): 924-925. (Research Centre for Biological Control of Coconut Black Headed Caterpillar, TNAU, Vaniyambadi, T.N.).

*Nephantis serinopa* Meyr. is one of the major pests of coconut in India. Attempts at laboratory mass-rearing of its parasite *Parasierola nephantidis* (Mues.) (*Perisierola nephantidis*) resulted in the production of females only. An investigation was therefore made to see whether unmated females of *Parasierola nephantidis* could parasitise *N. serinopa* to a useful degree. Females reared in the laboratory were confined with host larvae either before or after being allowed to mate. Unmated females laid eggs on the host and gave rise to males only, whereas mated females produced progeny of both sexes; both mated and unmated females had 3 reproductive cycles lasting 12-13 days each, with intervals of 4-5 days between. The successful parasitisation of hosts with male eggs by unmated females of *P. nephantidis* suggests that the latter can be used for the biological control of *N. serinopa*.

748. MUTHUKRISHNAN, P. and RANGARAJAN, M. 1976. Laboratory studies on the control of black-headed caterpillar *Nephantis serinopa* Meyr. by microorganisms. *Labdev J. Sci. Technol. Part B Life Sci.* 12(3):106-108.

The black-headed caterpillar, *N. serinopa* Meyr. is a serious leaf pest on coconut.

Laboratory studies on the control of this pest by microorganisms were conducted. Of the three microorganisms tested *Aspergillus flavus* L. and *Serratia marcescens* Bizio caused the greatest mortality while *Bacillus thuringiensis* Berliner was not effective in causing caterpillar mortality. Pathological observations are reported. Reisolations of the respective pathogens were successfully made from the dead caterpillars and also from the incomplete pupae.

749. MUTHURAMAN, M. 1984. Trunk injection of undiluted insecticides; method to control coconut red palm weevil, *Rhynchophorus ferrugineus* Fab. *Indian Cocon. J.* 15(2): 12-14. (Agric. College and Res. Institute, TNAU, Madurai, T. N.).

This study makes evident that root or stem injection of monocrotophos 10 ml/tree is effective in the control of both *Nephantis serinopa* and *Rhynchophorus ferrugineus*. Administering of 5 ml monocrotophos + 5 ml dichlorvos also proved to be successful in *R. ferrugineus* control. Placement of aluminium phosphide tablets (6 g) in the hole made by the pest was equally effective.

750. NADARAJAN, L. 1980. Control of coconut pests through stem injection of systemic insecticides. *Mysore J. Agric. Sci.* 14(3): 355-364. (Dept. of Entomology, UAS, Bangalore, Karnataka).

Several systemic insecticides were screened for the control of the coconut pests viz., the black-headed caterpillar *Nephantis serinopa* Meyr. and the red palm mite *Raoiella indica* Hirst through stem injection technique. In five year old palms monocrotophos at 3.5 ml, a.i./palm was effective and controlled the black-headed caterpillar population for 90 days. A dose of 7.0 ml a. i. of the same chemical was effective in 9-10 yr old palms as well as in palms over 45 years. The insecticide application was effective in protecting the palms for 60 days in both cases. Residues of different

insecticides in coconut water and coconut meat were within tolerance limits set by WHO/FAO three weeks after treatment indicating that the nuts were safe for consumption.

751. NADARAJAN, L. and CHANNABASAVANNA, G.P. 1980. Population dynamics of coconut black headed caterpillar, *Nephantis serinopa* Meyrick (Lepidoptera: Cryptophasidae) and its parasites. *Mysore J. Agric. Sci.* 14(4):533-541. (Dept. of Entomology, UAS, Bangalore, Karnataka).

Basic information on the ecology of coconut black headed caterpillar, *Nephantis serinopa* Meyr. as occurring 'around' Bangalore was collected and compared with that from Mangalore, a coastal area in Karnataka. The egg laying activity was more from Nov. to March and there was a steep increase of the early larval instars during the cooler months i.e., Nov. to Dec. Among the nine different parasites noted on the caterpillar pest, the efficient ones were the early larval braconid parasite, *Apanteles taragamae* Vier., the late larval parasite *Perisierola nephantidis* Muesebeck and the pupal chalcid parasite *Brachymeria* spp. The variation in temperature and humidity was narrow in Bangalore which did not influence the pest population much, as they also influenced the natural enemies. As against this, the extreme high temperature during summer in Mangalore, while favouring the pest to multiply faster, affected the natural enemies adversely.

752. NADARAJAN, L. and CHANNABASAVANNA, G.P. 1981. Trunk injection of systemic insecticides against the coconut black headed caterpillar *Nephantis serinopa* Meyrick (Lepidoptera: Cryptophasidae). *Oleagineux* 36(5): 239-245. (IARI, New Delhi).

The injection of monocrotophos (as Nuvacron) at 3.5 ml in coconut palms upto

5 years of age and at 7 ml in older palms controlled *N. serinopa* for 90 and 60 days, respectively. Dicrotophos (as Bidrin) was also effective. Phosphamidon (as Dimecron) was not effective at low concentrations and phytotoxic at high concentrations. Monocrotophos residues of coconut water (not detectable) and meat (0.06 ppm) with 3 weeks were below WHO/FAO tolerance limits.

753. NAIR, M. R. G. K. 1978. A monograph on crop pests of Kerala and their control. Trichur: Kerala Agricultural University. 162 p. (College of Agric., KAU, Trivandrum, Kerala).

The author presents a comprehensive review of the pests of cultivated crops in Kerala, India, and their control. Individual sections on the pests are given in chapters on the various types of crops including coconut. Data are presented on the morphology, biology, habits, ecology and natural enemies of the pests and the damage caused by them.

754. NAIR, M.R.G.K.; VISALAKSHI, A. and KOSHY, G. 1980. A new root-infesting mealy bug of coconut. *Entomon* 5(3): 245-246. (College of Agric., KAU, Trichur, Kerala).

A new species of the mealy bug *Rhizoecus* was found infesting roots of coconut in the sandy tracts of 'Trivandrum' district of Kerala, India in 1977. This was the first record of a species of this genus attacking the roots of coconut palm. The stages of the pest are described together with nature of damage.

755. NAMBIAR, S.S. and JOY, P.J. 1988. Pest management in coconut. In: Six decades of coconut research. Edited by M. Aravindakshan and others. Trichur: Kerala Agricultural University. p.103-113 (KAU, Trichur, Kerala).

This chapter on pest management on coconut is contained in a compendium which represents an attempt to present all the work on coconut carried out at various research

stations in Kerala, India, over the past 6 decades. The chapter contains information on research on *Oryctes rhinoceros* (mainly on varietal susceptibility, control using growth regulators, and natural enemies), *Rhynchophorus ferrugineus* (varietal susceptibility, insecticidal control and natural enemies), *Opisina arenosella* (control using insecticides and growth regulators, and natural enemies), *Leucopholis coneophora* (monitoring and insecticidal control), *Parasa lepida* and *Contheyla rotunda* (*Mambarilla rotunda*) (biology and natural enemies), *Paradasynus rostratus* (biology and insecticidal control), *Pseudococcus* sp. (damage caused and insecticidal control), minor pests and rodents.

756. NARENDRAN, T.C. 1979. Field incidence of *Nephantis serinopa* in the Malabar area of Kerala state. *Indian J. Plant. Prot.* 6(2): 91–92. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Coconut plantations in the Malabar region of India, were surveyed in 1977–78 for the incidence *Nephantis serinopa* Meyr. This pest was observed mainly in the coastal area. Its incidence in the region was shown to be very high, largest numbers being observed between February and May when the maximum temperature ranged from 32° to 35°C and the maximum mean humidity from 65 to 85.

757. NARENDRAN, T.C.; MOHAMED, U.V.K.; ABDURAHIMAN, U.C. and SUDHEENDRAKUMAR, V.V. 1981. Oviposition behaviour of *Bracon brevicornis* Wesmael (Hymenoptera: Braconidae). *Agric. Res. J. Kerala* 18 (2): 239–241. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

The ovipositional sequence in *Bracon brevicornis* is given. The prey is paralysed by the adult female before egg deposition. Eggs are deposited one by one, and on an average 25 eggs are deposited in a day.

758. NASSER, M. and ABDURAHIMAN, U.C. 1990. Reproductive biology and predatory behaviour of the anthocorid bug (Anthocoridae: Hemiptera) associated with the coconut caterpillar, *Opisina arenosella*. *Entomon* 15(3 & 4) : 149–158. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Some aspects of the biology of three predatory bugs, viz., *Cardiastethus exiguus*, *C. affinis* and *Buchananiella sodalis*, found in the galleries of *Opisina arenosella*, were studied. The life cycles of the three bugs are presented. The predatory and cannibalistic behaviour, reproductive biology and longevity of the adults were investigated. Field studies regarding their effectiveness as predators of *O. arenosella* were carried out and the findings discussed.

759. PATEL, A.J.; KAPADIA, M.N.; MITTAL, V.P. and JADEJA, K.D. 1987. Survey on the incidence of insect pests of coconut palm in Gujarat. *Indian Cocon. J.* 17(9):5–10. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

A survey on insect pests damaging coconut palm was carried out during the year 1983–84. *Opisina arenosella* Walker and *Oryctes rhinoceros* L. were observed to be well distributed. *Rhynchophorus ferrugineus* Fab. and stem borers viz. *Xyleborus perforans* Woolaston and *Diocalandra frumenti* Fab. were observed only in some palms. The *Opisina* and *Oryctes* infestation ranged from 0.27 to 38.41% leaflet damage and 0.10 to 22.07% palm damage, respectively. Infestation of stem borers was 1.07%. *Opisina* infests to a greater extent in Saurashtra, Kutch region and *Oryctes* more in middle-south Gujarat region.

760. PATEL, R.K.; SHAH, A.H. and JHALA, R.C. 1983. Residue status of monocrotophos in coconut water injected by stem injection technique. *Gujarat Agric. Univ. Res. J.* 10(2): 16–22. (N.M. College of Agric., GAU, Navasari Campus, Navasari, Gujarat).

The residue level of monocrotophos in coconut water was analysed by microbioassay at various periods after application of the insecticide at 3.6 or 7.2 g (a.i.) by trunk injection. Residues of the insecticide had fallen below the tolerance level of 2.2 ppm by the third or fourth weeks after application at lower and higher ratio respectively.

761. PATEL, R.K.; SHAH, A.H. and JHALA, R.C. 1984. Relative abundance of *Nephantis serinopa* Meyr. in three varieties of coconut grown in South Gujarat. *Indian Cocon. J.* 14(11): 5-8 (Dept. of Entomology, GAU, Navasari, Gujarat).

This study in south Gujarat reveals that the susceptibility of the three varieties of palms to *Nephantis serinopa* were in the order of Bona, T x D and WCT. Highest percentage infestation was negatively correlated with the height of the palm. Highest population of the pest was found in January-February and hence control measures should be initiated during November-December.

762. PHILIP, B.M.; MATHAI, S. and JACOB, A. 1982. A nuclear polyhedrosis of the black-headed caterpillar, *Nephantis serinopa* Meyrick (Lepidoptera: Cryptophasidae). *Curr. Sci.* 51(12): 611. (College of Agric., KAU, Trivandrum, Kerala).

Widespread larval mortality of *Opisina arenosella* Wlk. (*Nephantis serinopa* (Meyr.)), a serious pest of coconut all over the coastal regions of India, was observed in March and April, 1981 at Vellayani in Kerala state. Polyhedral bodies were found in the haemolymph and tissues of affected larvae, and symptoms produced included sluggishness, loss of appetite, oiliness and pink colour of the cuticle and death 3-8 days after infection, with rapid blackening after death. This is the first record of a virus affecting *O. arenosella*.

763. PILLAI, G.B. 1985. Coconut pests of national importance. In: Integrated pest and

disease management; proceedings of national seminar, TNAU, Coimbatore, 1985. Edited by S. Jayaraj. Coimbatore: TNAU. p.166-173. (CPCRI (RS), Kayangulam, Kerala).

The bio-ecology and damage potential of major pests and their management are highlighted in the paper.

764. PILLAI, G.B. 1987. Integrated pest management in plantation crops. *J. Coffee Res.* 17(1): 150-153. (CPCRI (RS), Kayangulam, Kerala).

Integrated management of the insect pests of coconut, cashew, pepper and cocoa was reviewed in this paper.

765. PILLAI, G.B. and BHAT, S. KESHAVA. 1986. Parasitism, development of progeny and sex-ratio of *Parasierola nephantidis* Mues. (Bethyilidae) on different instars of *Opisina arenosella* Wlk. (*Nephantis serinopa*) Meyr. *Indian Cocon. J.* 16 (11): 3-5. (CPCRI (RS), Kayangulam, Kerala).

Studies on the intensity of successful parasitism and development of progeny of *P. nephantidis* reared on different instars of *O. arenosella* caterpillars revealed that the stage of the host larvae used was critical in determining the acceptance by the parasitoid, number of eggs laid, number of offspring developed and the proportion of males in the brood. Fifth and early sixth instar caterpillars of *O. arenosella* were ideal stages of the host for large scale multiplication of *P. nephantidis* in the laboratory. The parasitoid was found to be capable of suppressing the early instar caterpillars of the pest by stinging, even though they were not ideal stages for the development of a good number of parasitoids.

766. PILLAI, G.B. and BHAT, S. KESHAVA. 1987. Biology and feeding potential of *Parena nigrolineata* (Chaudoir) (Coleoptera: Carabidae), a predator of the coconut caterpillar *Opisina*

*arenosella* Wlk. *Indian Cocon. J.* 17(12): 6-10. (CPCRI (RS), Kayangulam, Kerala).

A method to rear *P. nigrolineata* in the laboratory was developed. Biology and feeding potential of the predator both in the adult and immature stages are discussed. The rate of predation in the grub phase worked out to be 0.32 fourth instar caterpillar of *O. arenosella* per grub/day. Adult female beetle fed 0.34 and male beetle 0.31 fourth instar caterpillar/beetle/day. A scelionid *Xenomerus* sp. was recorded as an egg parasitoid of *P. nigrolineata* in the field. Intensity of its natural parasitism was quite high during rainy season and this was responsible for minimising the population of the beetle in the field.

767. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1981. Role of pupal parasitoids in the natural suppression of the coconut caterpillar, *Nephantis serinopa*, Meyrick. *J. Plantn Crops* 9(2): 84-87. (CPCRI (RS), Kayangulam, Kerala).

Evaluation of the intensity of natural parasitisation of *N. serinopa* pupae in Quilon and Allepey districts of Kerala during 1975 and in 1980 revealed that more than 50% of natural pest suppression was due to the pupal parasitoids of which the Chalcidids *Brachymeria* spp. were the major ones, and among them *B. nosatoi* was the most dominant species followed by *B. nephantidis*. Activity of *B. nosatoi* was more during the summer season, which is also the peak period of the pest. The intensity of natural parasitisation by *Trichospilus pupivora* was meagre.

768. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1982. Mating behaviour and biology of *Elasmus nephantidis* Rohw. (Hymenoptera: Elasmidae) a parasitoid of *Nephantis serinopa* Meyrick on coconut. *J. Plantn Crops* 10: 33-38. (CPCRI (RS), Kayangulam, Kerala).

Courtship and mating behaviour of *Elasmus nephantidis* Rohw., on the prepupal

caterpillars of *Nephantis serinopa* Meyrick include wing vibration, licking the antennae of the female with mouth parts, antennal stroking, leg tapping and post-copulatory biting on the female's abdomen. The female adopts a copulation posture by raising the abdomen and exposing the genital pocket on receiving sexual stimulation from the courting male. Males are capable of mating at very close intervals. Females allow courtship even when they are non-receptive and actually do not require further matings. Eggs are laid inside the host's cocoon one by one in groups after stinging and paralyzing the host. Egg to adult stages are completed in 11 days and longevity is shorter in summer than in winter. Sex ratio is normally female-biased. The merits and demerits of *E. nephantidis* as a biocontrol agent of *N. serinopa* are discussed.

769. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1982. A method to estimate the intensity of natural pupal parasitism of *Opisina arenosella* Wlk. (*Nephantis serinopa* Meyrick). *J. Plantn Crops* 10(2): 86-91. (CPCRI (RS), Kayangulam, Kerala).

The nature, size and position of the emergence holes made in the host pupal cases by different species of parasitoids of *O. arenosella* Wlk. were studied. These criteria were used in developing a method to estimate the intensity of natural parasitism of the pest and the relative contribution of individual species of parasitoids in the natural suppression of the pest. The advantages of the method are that it is fast, easy and accurate.

770. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1982. A note on *Trichospilus pupivora* Ferr., a parasite of *Nephantis serinopa* Meyr. *Entomon* 7(2): 225-226. (CPCRI (RS), Kayangulam, Kerala).

Laboratory and field observations carried out in India showed that part of the population of *Trichospilus pupivora* Ferr. a gregarious pupal

parasite of the coconut pest *Opisina arenosella* Wlk. (*Nephantis serinopa* Meyr.), aestivated in the pupal stage between March and May. The poor searching and dispersal ability of the parasite, its low tolerance to non-optimal temperatures, inability to discriminate between parasitised and unparasitised hosts leading to superparasitism and inability to compete with other pupal parasites were the major factors responsible for its inefficiency and low intensity of parasitism in the field.

771. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1982. A technique for laboratory multiplication of *Brachymeria nosatoi* Habu and other species of chalcidid parasitoids of *Nephantis serinopa* Meyrick. *Entomon* 7(2): 213-217. (CPCRI (RS), Kayangulam, Kerala).

A technique to mass rear the chalcidid *Brachymeria nosatoi* Habu, a solitary pupal parasite of the coconut pest *Opisina arenosella* Wlk. (*Nephantis serinopa* Meyr.), by simulating field conditions is described. The chalcidid oviposited in pupal cocoons that had been kept intact inside silken galleries. Other species of *Brachymeria*, such as *B. nephantidis* Gah., *B. himeatteave* Joseph, Narendran & Joy and *B. lasus* (Wlk.) could also be reared in the laboratory using this technique. Newly ecdysed pupae were accepted for parasitism as well as those at an advanced stage of development.

772. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1983. *Xanthopimpla nana* Schulz. (Hymenoptera: Ichneumonidae) A new pupal parasitoid of *Opisina arenosella* Wlk. on coconut. *J. Plantn Crops* 11(11): 65-67. (CPCRI (RS), Kayangulam, Kerala).

A new pupal parasite of *O. arenosella* Wlk., *Xanthopimpla nana nana* Schulz has been recorded in Kerala. It occurs in Java and Sri Lanka as well and play an important role in natural parasitism. Morphological differences between *Xanthopimpla punctata* and *X.nana*

*nana* has been discussed. Mating, oviposition and life span of the parasitoid have been studied.

773. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1986. Additions to the natural enemy complex of the coconut caterpillar *Opisina arenosella* Wlk. *J. Plantn Crops* 14(2): 138-140. (CPCRI (RS), Kayangulam, Kerala).

The coconut leaf-eating caterpillar, *Opisina arenosella* (Lepidoptera: Cryptophasidae) supports over 24 species of parasitoids and six species of predators in India and Sri Lanka. In a survey carried out for its natural enemies in the coastal and back water tracts of Quilon and Alleppey districts of Kerala, during 1983 and 1986 six species of predacious beetles, one tachinid, one ichneumonid and one chalcidid were added to the checklist of the natural enemy complex of *O. arenosella*. Details of the newly recorded species of predators and parasitoids, their taxonomic status and the stage of the pest which they feed and parasitize are also presented.

774. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1986. Observations on *Eriborus trochanteratus* Morley (Hymenoptera : Ichneumonidae), a larval parasitoid of *Opisina arenosella* Wlk. *J. Plantn Crops* 14(1): 11-14. (CPCRI (RS), Kayangulam, Kerala).

The populations of *Eriborus trochanteratus* (Morley) occurring in India and Sri Lanka, are morphologically identical, but belong to two biotypes. A method to rear the Sri Lankan biotype of *E. trochanteratus* using *Opisina arenosella* Wlk. as host in the laboratory was developed. Additional information on the mating behaviour, oviposition and life history of the parasitoid on *O. arenosella* and *Corcyra cephalonica* caterpillars was collected. Attempts on field colonisation of the laboratory reared parasitoids in *Opisina* infested coconut gardens in the West Coast of Kerala resulted in establishment and recovery. However, hyperparasitism by the chalcidid *Brachymeria*

*nephantidis* Gahan was observed in a few cocoons of *E.trochanteratus* collected from the release site. The possible reasons for the slow build up of population of *E.trochanteratus* in the field are also discussed.

775. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1987. *Brachycoryphus nursei* (Cameron) (Hymenoptera: Ichneumonidae), a parasitoid of *Opisina arenosella* Wlk. on coconut in Kerala, India. *J. Plantn Crops* 15(1): 9-14. (CPCRI (RS), Kayangulam, Kerala).

The cotton boll worm parasitoid *Brachycoryphus nursei* (Cameron) has been observed to occasionally parasitise the prepupae and pupae of the coconut leaf eating caterpillar in coconut gardens around Kayangulam, Kerala. This Indo-Pakistani species of solitary ectoparasitoid shows some peculiarities in host acceptance, oviposition and development. It attacks the larvae, prepupae and pupae; always deposits numerous eggs on the host eventually producing only one individual parasitoid. Occasionally it develops internally in the host pupae. It has high fecundity but possesses low searching ability, thereby causes only negligible percentage parasitism in *O. arenosella*. Eggs are laid after keeping the ovipositor contacting the paralysed host. Feeding on the host haemolymph is observed throughout the life span of the female parasitoid. The larvae of *B. nursei* are cannibalistic. This parasitoid produces more females than males in the field. The females are polyandrous and males vigorous. Method of rearing, oviposition, development and life cycle of the parasitoid are discussed.

776. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1987. Observations on *Xanthopimpla* sp. (Hymenoptera: Ichneumonidae), a pupal parasite of *Opisina arenosella* Wlk. on coconut in Kerala. *J. Biol. Control* 1(1):7-10 (CPCRI (RS), Kayangulam, Kerala).

The biology of *Xanthopimpla* sp. a pupal parasitoid of the xyloxyctid coconut pest *Opisina arenosella*, was studied in the laboratory at 22-30°C and 45-80% RH. Pupae of the noctuid *Anadevidia peponis* and the pyralids *Margaronia indica*, *Sylepta derogata* and *O. arenosella* were used as laboratory hosts. The mating and oviposition behaviour of the parasitoid are described. In pupae of *O. arenosella*, *S. derogata* and *M. indica* the life cycle lasted 12-16 days, while in *A. peponis* it took 13-20 days. The egg, larval, pupal and preoviposition periods lasted 28-30 h, 6-13 days, 5-9 days and 3 days respectively. Females parasitized 2-6 hosts/day and their longevity was 1-4 months. The morphology of each developmental stage is described.

777. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1989. Observations of *Xanthopimpla punctata* F. (Hymenoptera: Ichneumonidae), a pupal parasitoid of *Opisina arenosella*. *J. Plantn Crops* 16(Suppl.): 173-177. (CPCRI (RS), Kayangulam, Kerala).

On the basis of laboratory and field studies carried out in Kerala and Tamil Nadu, India, in 1981-84, details are given of the life history and mating behaviour of *Xanthopimpla punctata*, a parasitoid of the coconut pest *Opisina arenosella*. Oviposition was found to be preceded by host feeding. Percentage parasitism by all species of parasitoids at various sites ranged from 49.27 to 64.59 and that by *X. punctata* from 26.50 to 43.59.

778. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1990. On the biology of *Calleida splendidula* (F) (Coleoptera: Carabidae) predator of the coconut leaf eating caterpillar *Opisina arenosella* Wlk. *Indian Cocon. J.* 20(12): 14-17 (CPCRI (RS), Kayangulam, Kerala).

A method for rearing the carabid predator, *Calleida splendidula* (F) in the laboratory is described. Short descriptions of the adult and

Immature stages of the beetle and feeding potential of the predator on *Opisina arenosella* Wlk. caterpillars are also furnished. The adult beetle, on an average, consumed one fully grown caterpillar of *O. arenosella* in every three days. Eleven to thirteen second instar caterpillars of *O. arenosella* were consumed by each grub during the entire grub phase. The adult beetle lived for 6 to 14 months in laboratory cages. A comparison between *C. splendidula* and *Parena nigrolineata* (Chaudoir) also is furnished.

779. PILLAI, G.B. and RAMACHANDRAN NAIR, K. 1990. Role of Ichneumonid parasitoids in the biological suppression of coconut leaf eating caterpillar *Opisina arenosella* Wlk. *Indian Cocon. J.* 21(4): 3-10. (CPCRI (RS), Kayangulam, Kerala).

Role of six species of Ichneumonid parasitoids with regard to their bio-ecology and the role in effecting natural biological suppression of *O. arenosella* are discussed in the paper.

780. PONNAMMA, K.N. 1984. Field studies on the comparative efficacy of BHC, dichlorvos and trichlorphon for the control of *Opisina arenosella* Wlk. (*Nephantis serinopa* M.). *Indian Cocon. J.* 15(7): 3-5. (CPCRI (RS), Kayangulam, Kerala).

On the 7th day after application, dichlorvos (0.02%), BHC (HCH) (0.2%) or trichlorphon (0.06%) reduced *O. arenosella* infestation on coconut palms by 81.49, 63.66 and 63.4%, respectively.

781. PONNAMMA, K.N. and ABRAHAM, V.A. 1985. Laboratory evaluation of five insecticides for the control of the Ash weevil, *Mylokerus curvicornis* (F.); a newly recorded pest of coconut palm. *Indian Cocon. J.* 15(12): 12. (CPCRI (RS), Kayangulam, Kerala).

A number of insecticides were tested for the control of the Ash weevil and results given.

782. PONNAMMA, K.N.; ABRAHAM, V.A.; KURIAN, CHANDY and GEORGE, M.V. 1981. The host preference of *Mylokerus curvicornis* (F.); a pest of coconut palm. *Agric. Res. J. Kerala* 19(2): 111-114. (CPCRI (RS), Kayangulam, Kerala).

The leaf disc feeding method was used in laboratory studies to determine the preference of *Mylokerus curvicornis* (F.), a pest of coconut, for six food plants. The most preferred food-plant was *Stylosanthes gracilis*, followed by *Glyricidia indica* and mango. When the feeding rates were determined during different months, *S. gracilis* was markedly preferred in March and *S. gracilis* and *G. indica* were preferred in June, July and September. *S. gracilis* and *G. indica* which are grown as intercrops in coconut plantations, serve as food plants of *M. curvicornis*.

783. PONNAMMA, K.N.; CECIL, S. ROBERT; KURIAN CHANDY; ABRAHAM, V.A. and NAMBIAR, P.T.N. 1985. Relation between incidence of *Mylokerus curvicornis* (F.) and intensity of root (wilt) disease in coconut cultivars and hybrids. *J. Plantn Crops* 13(1): 69-73. (CPCRI (RS), Kayangulam, Kerala).

The eight healthiest palms from each group of 12, each group representing one of 37 coconut cultivars and hybrids under test, were assessed for leaf damage by *M. curvicornis*. Malayan Dwarf Green showed the highest leaf damage (69.7% for plants directly introduced from Malaysia, and 59.27% for those from Kulasekharan). Cultivars British Solomon Islands and Fiji x SS Green showed least damage (8.33% and 7.29%, respectively). Root (wilt) diseased palms suffered greater leaf damage from weevils than did healthy palms and this was related to high nitrogen content of diseased palms:

784. PONNAMMA, K.N.; KAMALAKSHY AMMA, P.G.; KURIAN, CHANDY and NAMBIAR, P.T.N. 1982. Incidence of *Mylokerus curvicornis* F.

in relation to nutritional status of coconut palms. *Philipp. J. Cocon. Studies* 7(1/2): 40–41. (CPCRI (RS), Kayangulam, Kerala).

*M. curvicornis* (F.) is a new pest on coconut. It was observed damaging coconut foliage. This paper presents the observation of its abundance in relation to nutritional status of Dwarf x Tall palms. Results revealed that pest intensity was significantly higher in  $N_2P_2K_2$  plots than in  $N_1P_1K_1$ ; the percentage of infestation being 54.68%, 71.21% and 68.31% for  $N_1P_1K_1$ ,  $N_2P_2K_2$  and  $N_3P_3K_3$  respectively.

785. PONNAMMA, K.N. and KURIAN, CHANDY. 1979. Effect of nutrition on longevity of *Bracon brevicornis* Wesmael (Hymenoptera: Braconidae), a larval parasitoid of the coconut caterpillar *Nephantis serinopa* Meyrick. In: Symposium on Plantation Crops, 2nd, Ootacamund, Jun. 26–29, 1979. Proceedings of PLACROSYM II. Edited by C.S. Venkataram and others. p. 510–512. (CPCRI (RS), Kayangulam, Kerala).

*Bracon brevicornis* Wesmael (Braconidae) is an important indigenous larval parasitoid of *Nephantis serinopa*. The adult parasitoids are usually fed in diluted honey in the laboratory. The present study assesses the efficacy of different sugars such as xylose, dextrose, sorbose, mannose, mannitol, sucrose and raffinose in comparison with honey and distilled water in increasing longevity of *B. brevicornis*. The parasitoids were fed daily with 20% solutions of sugars, honey and distilled water as droplets on wax-coated paper. Honey improves the life span, the longevity being 10.4 days for males and 30.1 days for females. This was followed by sucrose and dextrose.

786. PONNAMMA, K.N. and KURIAN, CHANDY 1986. Record of *Syntomis passalis* Fab. (Lepidoptera: Arctiidae: Tenuchinae) as a pest on coconut inflorescence. *Indian Cocon. J.* 16(7): 3–4. (CPCRI (RS), Kayangulam, Kerala).

A brief account on a new caterpillar pest *Syntomis passalis* has been presented. The caterpillars are black and beset with urticating hairs. Moths are brightly coloured having scaleless spots on wings. Infestation occurs on spathes and buttons, causing heavy button shedding.

787. PONNAMMA, K.N.; KURIAN, CHANDY; SUKUMARAN, A.S. and KOYA, K.M. ABDULLA. 1985. Field evaluation of BHC, carbaryl and endosulfan for the control of the coconut coreid bug *Paradasynus rostratus* Distant. *Indian Cocon. J.* 15(10): 10–11. (CPCRI (RS), Kayangulam, Kerala).

Field evaluation of BHC, carbaryl and endosulfan for the control of coconut coreid bug *Paradasynus rostratus* Dist. was carried out. It is found advisable to use carbaryl 0.05% or endosulfan 0.1% for controlling coreid bug.

788. PUROHIT, M.S.; PATEL, G.M. and SHAH, A.H. 1988. First incidence of coconut leaf weevil, *Diocalandra frumenti* F. in Gujarat. *Indian Cocon. J.* 19(5): 11. (N.M. College of Agric., GAU, Navasari Campus, Navasari, Gujarat).

Coconut leaf weevil is reported from coconut plantations in Navasari for the first time. The larvae feed on leaf bases tunneling the soft tissues. Brownish exudation comes out of the infested part. Brief description is given on the stages of the pest.

789. RADHAKRISHNAN, R. 1987. Some field observations on the infestation of mealy bug and its management problems in coconut. *Indian Cocon. J.* 17(11): 14–25. (Agric. Sub Div., Attingal, Kerala).

Mealy bug is one of the insect pests responsible for nut fall in coconut, right from button stage upto mature nuts. The need for a detailed study on the infestation of the pest with special emphasis on the extent of damage on unopened spathe and loss of yield is

highlighted. The reasons for the co-existence of the coreid and mealy bug are to be studied. It is quite common that healthy trees with severe infestation of mealy bugs have even five barren bunches in their crown. Infestation on spathe affects the vigour of the inflorescence. This pest could be controlled for a short period by spraying with dimethoate.

790. RADHAKRISHNAN, R. 1988. A new symptom of attack of leaf rot observed in Attingal Agric. Sub Division and its management problems. *Indian Cocon. J.* 19(7): 9. (Agric. Sub. Div., Attingal, Kerala).

The new symptom of attack pointed out here has been observed in Varkala, Chirayinkil and Ulloor Units of Attingal Sub Division. Though the problem is on the management of leaf rot disease, it forms part of the series of observations made on the infestation of mealy bug in coconut for the last two years. It is worthwhile to study whether the mealy bug and its carrier have any role in the spread of leaf rot disease other than air transmission.

791. RAGHUNATH, T.A.V.S. and SUBRAMANYAN. 1981. On the occurrence of the hairy caterpillar *Dasychira mendosa* (Hubner) on coconut. *Indian Cocon. J.* 12(4): 4.

The hairy caterpillar *Dasychira mendosa* Hubn. a polyphagous pest has been reported for the first time in Andhra Pradesh on coconut palm. The caterpillars of the pest gregariously feed on the tender leaves of the palm.

792. RAHALKAR, G.W.; HARWALKAR, M.R.; RANANAVARE, H.D.; KURIAN, CHANDY; ABRAHAM, V.A. and KOYA, K.M. ABDULLA. 1977. Preliminary field studies on the control of the red palm weevil *Rhynchophorus ferrugineus* Oliv. using radiosterilized males. *J. Nucl. Agric. Biol.* 6(3): 65-68. (Biology and Agric. Div., BARC, Trombay, Bombay, Maharashtra).

Feasibility of using sterile male release method for the control of red palm weevil,

*Rhynchophorus ferrugineus* Oliv. in India was investigated. A total of over 5000 radiosterilized males were released in an 800 acre coconut plantation near Kayangulam in Kerala. Data on the fertility pattern of native females are presented and the factors affecting the efficacy of sterile male release for control of this insect are discussed.

793. RAHALKAR, G.W.; SHANTARAM, K.; HARWALKAR, M.R. and RANANAVARE, H.D. 1982. Mating, competitiveness and effective life of the radiation sterilized male red palm weevil *Rhynchophorus ferrugineus* Oliv. In : Sterile insect technique and radiation insect control. Vienna: IAEA. p.395-400. (Biology and Agric. Div.; BARC, Trombay, Bombay, Maharashtra).

The feasibility of using the sterile insect technique for controlling the red palm weevil, *R. ferrugineus* a serious pest of coconut and other cultivated palms in India, is being evaluated. In this insect an X or gamma-ray dose of 1.4 krad induces about 90% sterility in males, who survive for 90-100 days compared with 100-110 days of control insects. Since the sterile males would survive for such a long period after their release in the field it was of interest to evaluate their mating competitiveness as they advance in age in order to determine their effective life. Data from sex ratio experiments indicated that mating competitiveness is reduced by about 50% by the time the sterile male is half way through its life expectancy. Reduction in the overall competitiveness could not be attributed only to the reduction in their mating ability but also to depletion in sperm production during aging. Results are discussed in the light of the precedence in sperm utilization in this insect.

794. RAJAN, P. and MATHEN, K. 1984. *Sophonia greeni* (Distant) (Nirvanidae: Jassoidea) on leaves of coconut palm, *Cocos nucifera* L. *J. Plantn Crops* 12(2): 178-179. (CPCRI (RS),

Kayangulam, Kerala).

Observation of young coconut seedlings at CPCRI (RS) Farm, Kayangulam revealed the tender leaves harbouring pale yellow, depressed active leaf hoppers identified as *Sophonia (Nirvana) greeni*. Distant. This is a new record on coconut. The hopper is found to feed on tender leaves of palms of all age groups. It feeds and breeds on coconut.

795. RAJAN, P. and MATHEN, K. 1985. *Proutista moesta* (Westwood) and other additions to insect fauna on coconut palm. *J. Plantn Crops* 13(2): 135-136. (CPCRI (RS), Kayangulam, Kerala).

Close examination of 500 coconut seedlings for insect association with regard to root (wilt) proved that population of *Proutista moesta* (Westwood) was prominent throughout the year. *P. moesta* feeds on coconut leaflets belonging to outer or middle whorls, laid eggs in captivity on coconut leaflets, but did not hatch and they eventually dried. Immature stages of the insect were never observed on the coconut leaf.

796. RAMACHANDRAN, C.P. and PONNAMMA, K.N. 1984. Residual toxicity of BHC and malathion to the larval and pupal parasites of *Opisina arenosella* Walker (*Nephantis serinopa* M.) *Philipp. J. Cocon. Studies* 9(12): 18-22. (CPCRI (RS), Kayangulam, Kerala).

Residual toxicity tests of BHC and malathion were carried out against laboratory-bred parasites. Both the insecticides at recommended doses for the control of *O. arenosella* were found to be highly toxic to all the laboratory bred parasites, except BHC to the bethylids. Malathion was found to be more toxic to parasites than BHC. The residual toxicity of insecticides to parasites varied from period to period and parasite to parasite.

797. RAMACHANDRAN, C.P.; PONNAMMA, K.N.; KOYA, K.M. ABDULLA and KURIAN, CHANDY. 1979. The coconut leaf eating

caterpillar, *Nephantis serinopa* Meyrick, a review. *Philipp. J. Cocon. Studies* 4(2): 9-17. (CPCRI (RS), Kayangulam, Kerala).

Work conducted on the life history, habits, seasonal abundance, natural enemies, biological and chemical control, as well as integrated control of the coconut leaf eating caterpillar, *Nephantis serinopa* Meyr. is reviewed. Problem areas on the control of this serious pest in India and Sri Lanka have been identified. Additional studies for each aspect of the pest are suggested to evolve a feasible integrated control schedule.

798. RANJITH, A.M.; RAZAK, M.P. ABDUL. and SUMANGALA S. NAMBIAR. 1988. Influence of weather on the larval populations of cockchafer beetles in coconut. In: National Seminar on Agrometeorology of Plantation Crops, RARS, KAU, Pilicode, Mar. 12-13, 1987. Proceedings of seminar. p.83-89. (RARS, KAU, Pilicode, Kerala).

The abundance of white grubs in the root environment of coconut palms was under the influence of mean monthly rainfall and was negatively correlated with mean maximum temperature. The populations were higher during June and July than during February to May. The top 80 cm of the soil harboured the maximum number of grubs. It is advocated that prophylactic insecticidal treatment of the top layer of soil during the period of heavy rainfall will aid in reducing the pest build-up in endemic areas.

799. RAO, A. GANESWARA; LAXMINARAYANA, K. and RAO, P. RAMAMOHAN. 1980. Administration of systemic insecticide through root - a new method of control of red palm weevil *Rhynchophorus ferrugineus* Fab. in coconut. *Indian Cocon. J.* 11(2): 5-6. (Parasite Breeding Station, Ambajipet, A.P.).

*Rhynchophorus ferrugineus* Fab. the most destructive pest of coconut palm has been discussed in this paper. A method for root

application of suitable pesticides also presented.

800. RAO, A. GANESHWARA; RAO, P. RAMAMOCHAN; LAXMINARAYANA, K. and THAMMI RAJU, N.B. 1981. Studies on the effect of trunk injection of systemic insecticides for the control of *Nephantis serinopa* Meyrick in coconut. *Indian Cocon. J.* 12(5): 1-3. (Parasite Breeding Station, Ambajipet, A.P.).

Trials were carried out for two years with 15-20 year old coconut palms (cv. unspecified) which were heavily infested by *N. serinopa*. Two of the 4 insecticides tested were found ineffective, but monocrotophos or dicrotophos, each at 5, 10 or 15 ml/palm, gave very good control, and their residual effect persisted upto 60 days. The lowest dose of 5 ml/palm was the most economical.

801. RAO, A. GANESWARA; RAO, P. RAMA MOHAN; LAXMINARAYANA, K. and RAO, P. SANJEEVA. 1978. Preliminary observations on the biology of *Parena laticincta* Bates (Coleoptera: Carabidae), a predator of *Nephantis serinopa* Meyrick. *Indian Cocon. J.* 9(1): 2-5. (Parasite Breeding Station, Ambajipet, A.P.).

Biology, habits, field activity and abundance of the predator were discussed.

802. RAO, A. GANESWARA; RAO, P. RAMA MOHAN and RAO, T. RAMAMOCHAN. 1989. Studies on the effect of root feeding of systemic insecticides in the control of red palm weevil, *Rhynchophorus ferrugineus* Fab. in coconut. *Indian Cocon. J.* 19(9): 12-16. (Parasite Breeding Station, Ambajipet, A.P.).

Relative effectiveness of root feeding of seven insecticides was assessed. None of the insecticides except monocrotophos @ 10 ml/palm diluted with equal quantity of water was found to give optimum lethal dose. The cost of the treatment was worked out and merits of root feeding method are also discussed.

803. RAO, A. GANESWARA; RAO, P. RAMA

MOHAN; THAMMI RAJU, N.B.; LAXMINARAYANA, K.; RAO, B.H. KRISHNA MURTHY and MURTHY, SATYANARAYANA. 1980. Administration of systemic insecticide through root - a new method of control of coconut black headed caterpillar *Nephantis serinopa*, Meyr. *Indian Cocon. J.* 11(1): 3-5. (Parasite Breeding Station, Ambajipet, A.P.).

Chemical control of *Nephantis serinopa* poses serious limitations and spray recommendations given so far are somewhat difficult with tall coconut palms. A new method of administering of systemic insecticide through root was adopted at the Parasite Breeding Station of Ambajipet and found effective against *N. serinopa*. This method obviates harmful effects against beneficial parasites and predators and avoids hazards to the operator.

804. RAO, A. GANESWARA; THAMMI RAJU, N.B. and LAXMINARAYANA, K. 1978. *Elymnias hypermnestra undularis* (Drury) - a new pest of coconut in India. *Indian Cocon. J.* 9(8): 3. (Parasite Breeding Station, Ambajipet, A.P.).

A description of the eggs, caterpillars and adults of this newly identified pest is given.

805. RAO, D. MALLIKARJUNA and AZAM, K.M. 1984. New records of *Brachymeria* spp. a pupal parasite of coconut caterpillar *Nephantis serinopa* M. in Andhra Pradesh. (Parasite Breeding Station, APAU, Ambajipet, A.P.).

Studies carried out during 1971-'72 revealed the presence of two species of pupal parasites viz., *Brachymeria himeattevae* Joseph and *B. lasus* Walker in coconut belt of Andhra Pradesh. These are new records in the state.

806. RAO, D. MALLIKARJUNA and AZAM, K.M. 1985. Studies on *Trichogramma australicum* (Girault) as an egg parasite for the biological control of the coconut leaf caterpillar *Nephantis serinopa* Meyrick. *Indian Cocon. J.* 15(10): 12. (Parasite Breeding Station, APAU, Ambajipet, A.P.).

Details on the biology of the parasite are given. Mass multiplication of this parasite on the eggs of *Corcyra cephalonica*, an alternate host in the laboratory and effect of releasing parasitised egg of the alternate host in the pest infested coconut field for biological suppression of *N. serinopa* are explained in the paper.

**807. RAO, B. NARASIMHA and MURTHY, K.S.R.K.** 1985. Residues of monocrotophos in coconut water and copra when administered through root. *Indian Cocon. J.* **16(1):** 7-9. (Dept. of Entomology, College of Agric. APAU, Hyderabad, A.P.).

The findings indicated that residues of monocrotophos dissipated to below tolerance limit of 0.1 ppm (FAO/WHO) in 72, 76, 94 and 66 days for water in tender coconut, water in mature coconut, tender copra and mature copra, respectively.

**808. RAO, P. RAMA MOHAN; RAO, A. GANESWARA and LAXMINARAYANA, K.** 1986. Effect of natural and alternate host combination on the performance of *Parasierola nephantidis* M. and *Bracon hebetor* Sey; the larval parasitoids of *Opisina arenosella* Wlk. *Indian Cocon. J.* **17(2):** 1-4. (Agric. Res. Station, Ambajipet, A.P.).

Four combinations of the laboratory host and natural host were employed in the rearing of the parasitoid. Studies indicated that higher parasitoid production can be obtained by rearing the parasitoid continuously on *O. arenosella* in respect of *P. nephantidis* and on *Corcyra cephalonica* in respect of *B. hebetor*. However, for ultimate parasitization of the larvae of the pest without any deleterious effect, breeding of *B. hebetor* on *O. arenosella* and *C. cephalonica* alternatively was found to be the best.

**809. REDDY, M. VIKRAM.** 1984. First record of *Odontotermes bellahunisensis* Holmg. & Holmg. feeding on *Cocos nucifera* Linn. *J. Bombay Nat. Hist. Soc.* **80(3):** 653 (College of Agric.,

*Odontotermes obesus* was recorded as a serious pest attacking both coconut saplings and mature palms in the coconut plantations on laterite soils in the coastal belt between Gopalpur and Chatoapur, Ganjam (Orissa). Besides, *O. bellahunisensis* was recorded feeding on both young and mature palms in the areas, which is the first record in the eastern zone including Bangladesh. Its damage to coconut palm in the plantations is described in detail.

**810. REMADEVI, O.K.; ABDURAHIMAN, U.C.; MOHAMMED, U.V.K. and BEENA, C.G.** 1980. Biology and behaviour of *Trichospilus pupivora* (Hymenoptera: Eulophidae) with a note on its field parasitism of *Nephantis serinopa* (Lepidoptera: Xylorictidae). *Ceylon Cocon. Q.* **31(4):** 119-126. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

The pupal parasite, *Trichospilus pupivora* Ferr. is widely used for the biological control of the coconut caterpillar pest *Nephantis serinopa* Meyr. The life history and behaviour of this parasite are studied in some detail. The eggs are measuring  $183 \pm 15 \mu$  in length and  $65 \pm 8 \mu$  in width. The incubation period is 24 to 30 h. The larval period extends for 5 to 6 days and the pupal period for 7 to 8 days. Mating takes place before the emergence from the host pupae. In addition to the 30 or more hosts already reported this insect was also found to parasitise *Udaspes folus*, *Anigraea albomaculata* and the pre-pupae and pupae of Vespidae and Sphecidae.

**811. REMADEVI, O.K.; MOHAMMED, U.V.K. and ABDURAHIMAN, U.C.** 1980. Notes on *Megaselia* sp. (Diptera: Phoridae); a newly recorded parasite of *Nephantis serinopa* Meyrick (Lepidoptera: Xylorictidae). *Curr. Sci.* **49(12):** 491-492. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

Species of *Megaselia* as parasites of coccinellids, myriapods and grasshoppers have been studied. The immature stages of *Megaselia* sp were obtained from the pupae of *Nephantis serinopa* found parasitised by these dipterans. The adult insects were fed with honey or sugar solution. Fresh pupae of *N. serinopa* were supplied in order to observe their parasitic nature.

812. REMADEVI, O.K.; MOHAMMED, U.V.K.; ABDURAHIMAN, U.C. and BEENA, C.G. 1980. Biological observations of *Bracon brevicornis* (Hymenoptera: Braconidae), the biological control agent of *Nephantis serinopa* (Lepidoptera: Xylorictidae). *J. Sci. Res.* 2(3): 197–200. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

*Bracon brevicornis* Wesmael is one of the biological control agents employed against *Nephantis serinopa* Meyr., the black headed caterpillar pest of coconut palms. The adult female lays its egg on the host body after paralysing it by stinging. There are five larval instars. The duration of development from egg to adult takes about 7–8.5 days. Males predominate on the proportion of sexes. The females live longer than the males. The life history, mating, oviposition, nutrition, longevity and sex-ratio of this important species of *Bracon* are described and discussed.

813. REMADEVI, O.K.; MOHAMMED, U.V.K.; ABDURAHIMAN, U.C. and NARENDRAN, T.C. 1978. Oviposition behaviour of *Perisierola nephantidis* Muesebeck (Bethyridae: Hymenoptera); a larval parasite of *Nephantis serinopa* Meyrick (Xylorictidae: Lepidoptera). *Entomon.* 3(2): 303–305. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

*Perisierola nephantidis* deposits eggs on the late instar caterpillar of *Nephantis serinopa*. It begins oviposition 4–5 days after emergence. The host larva is being stung and paralysed before oviposition.

814. SADAKATHULLA, S. 1986. The black headed caterpillar of coconut and its management. In: "Pest and disease management – oil seeds, pulses, millets and cotton." Edited by S. Jayaraj. Coimbatore: CPPS, TNAU. 1986. p.69–75. (RARS, TNAU, Veppankulam, T.N.).

The habitat, damage potential and biology of the coconut black headed caterpillar *Opisina arenosella* Wlk. and the achievements made in its IPM are discussed.

815. SADAKATHULLA, S. and RAMACHANDRAN, T.K. 1990. Evaluation of insecticides against termite, *Odontotermes obesus* Ramb. (Termitidae: Isoptera), attacking palm and plaited leaves of coconut. *Indian Cocon. J.* 21(1): 11–13. (RARS, TNAU, Veppankulam, T.N.).

The *in vivo* experiments showed the significant superiority of spray with aldrin 0.15% or HCH 0.25% or chlordane 0.1% or DDT 0.25% on the base and upto 2 metre height of the trunk of coconut palm in control of *O. obesus* and aldrin 0.15% or chlordane 0.1% on the plaited coconut leaves even when the plaited leaves were kept on the bare ground having continuous occurrence of this subterranean pest.

816. SADAKATHULLA, S. and RAMACHANDRAN, T.K. 1990. A novel method to control rhinoceros beetle, *Oryctes rhinoceros* L. in coconut. *Indian Cocon. J.* 21(7–8): 10–12. (RARS, TNAU, Veppankulam, T.N.).

Different insecticide formulations were tried and evaluated in the base of the interspaces of leaf sheath of three top most leaves in the crown of 4 to 5 year old coconut palms. All the chemical treatments were found distinctly superior to untreated control. Application of naphthalene balls (weighing 3.5 g each) @ 3 per palm at 45 days interval protected palms effectively against rhinoceros beetle as that of

application of HCH 10% + sand at ratio 1:1.

817. SANKARAN, T. 1977. Natural enemies introduced in recent years for biological control of agricultural pests in India. *Indian J. agric. Sci.* 44(8): 425-433. (Commonwealth Institute of Biological Control, Indian Station, Bangalore, Karnataka).

The insect, snail and weed pests of Indian crops are listed, together with the insects and predators imported for their control. Specific crops mentioned are apple, cabbage, castor, coconut, cotton, potato, rice and sugar.

818. SANTHOSH BABU, P.B. and PRABHU, V.K.K. 1987. How many larval instars are there in *Opisina arenosella*? *Entomon* 12(1): 39-42. (Dept. of Zoology, Univ. of Kerala, Trivandrum, Kerala).

Detailed laboratory studies at ambient conditions of 23°-32°C and 75-90% RH at 12:12 photo period show that the insect *O. arenosella* has eight larval instars; the ratio of head capsule width of successive instars is more or less constant and ranging between 1.2 and 1.7. The graph showing log head capsule width and instar is a straight line.

819. SARKAR, B.B. 1986. Control of coconut pests in north eastern hill region. *Indian Cocon. J.* 16(11): 3-8. (Plant Protection Research Centre, State Agric. Res. Station, Arundatinagara, Tripura).

A field survey on pests and integrated pest management trials were conducted at various research stations in Assam and Tripura states. Pests identified so far, problems faced by the region and control measures have been discussed.

820. SATHIAMMA, B.; ABRAHAM, V.A. and KURIAN, CHANDY. 1981. The leaf roller *Suastus gremius* Feab. (Lepidoptera: Hesperiiidae) a minor pest of coconut palm. *Indian Cocon. J.* 12(2): 6-7. (CPCRI (RS), Kayangulam, Kerala).

Detailed biology of the pest has been studied under laboratory conditions. Egg to adult period ranged from 36 to 47 days. The paper also described about the host range, natural enemies and control measures of the pest.

821. SATHIAMMA, B.; ABRAHAM, V.A. and KURIAN, CHANDY. 1982. Integrated pest management of the major pests of coconut. *Indian Cocon. J.* 12(6-9): 27-29. (CPCRI (RS), Kayangulam, Kerala).

*Oryctes rhinoceros*, *Nephantis serinopa*, *Rhynchophorus ferrugineus* and *Leucopholis coneophora* are the major pests of coconut among 830 insects and mites species reported to be associated with coconut palm. Mechanical and biological control methods are being used other than the use of pesticides to keep these pests under check. Integrated pest management incorporating all these known methods is the most successful and economical control measure.

822. SATHIAMMA, B.; JAYAPAL, S.P. and PILLAI, G.B. 1985. Record of *Ankylopteryx octopunctata candida* (Fabricius) (Neuroptera: Chrysopidae), as egg and larval predator on *Opisina arenosella* Wlk.; the leaf eating caterpillar of the coconut palm. *Curr. Sci.* 54(21): 1128. (CPCRI (RS), Kayangulam, Kerala).

Larvae of *Ankylopteryx octopunctata candida* were observed to prey on eggs and early instar larvae of the xyloxyctid coconut pest, *Opisina arenosella*, in Kerala, in 1982. The adults of *A. octopunctata* are described. They are nocturnal and during day they rest on leaflets of the coconut palm. Feeding trials revealed that each first instar larva consumed 2-3 eggs of *O. arenosella* / day. Females of *A. octopunctata* laid pedunculate eggs in batches on the infested coconut leaflets, which hatched in about two days. The larval period ranged from 9-11 days and there were three larval instars. Pupation occurred in or near the leaf

axils, and the pupal period ranged from 10–12 days. The average life span of *A. octopunctata* reared on honey in the laboratory was 50–72 days for the female and 17–35 days for the male. The predator appeared in the field from April–October, and the population peaked in June and July.

**823. SATHIAMMA, B.; PILLAI, G.B.; ABRAHAM, JOSE; BHAT, S. KESHA; JAYAPAL, S.P. and RAMACHANDRAN NAIR, K. 1987.** Norms for release of larval, prepupal and pupal parasitoids of *Opisina arenosella* Wlk. the leaf eating caterpillar of the coconut palm. *J. Plantn Crops* 15(2): 118–122. (CPCRI (RS), Kayangulam, Kerala).

An experiment was conducted to work out the dosages for release of the larval, prepupal and pupal parasitoids of *O. arenosella* under field conditions. Parasite releases were made at three doses viz., 0, 25 and 50% of the target stages of the pest population at fortnightly intervals. Observations revealed that the releases of the parasites effected varying levels of reduction in population density of *O. arenosella*. The reduction obtained was significant in plots in which the larval parasitoid *Goniozus nephantidis* and the prepupal parasitoid *Elasmus nephantidis* were released. The doses worked out were 20.5% for *G. nephantidis*, 49.4% for *E. nephantidis* and 31.9% for *B. nosatoi* when the parasitoids were released individually, and 40.4% when a combined release was made.

**824. SATHIAMMA, B.; PILLAI, G.B. and JAYAPAL, S.P. 1986.** Bioecology of *Bracon hebetor* Say. (Hymenoptera: Braconidae) an indigenous larval parasitoid of the coconut leaf eating caterpillar *Opisina arenosella* Wlk. (Lepidoptera: Cryptophasidae). *J. Plantn Crops* 14(2): 140–146. (CPCRI (RS), Kayangulam, Kerala).

During a survey on the natural enemy complex of the coconut leaf eating caterpillar, *O. arenosella* cocoons and adults of a braconid

parasitoid were collected from Eravipuram, Quilon District, Kerala. Subsequently, this species was also collected from other *Opisina* infested gardens at Ponmana and Ayiramthengu (Quilon District), Thottappally (Alleppey District) and Nileshtar (Cannanore District). The specimens reared in the laboratory from field collected cocoons were determined as *Bracon hebetor* (*Microbracon hebetor* (*Habrobracon juglandis*)). The biology, parasitic behaviour and intensity of natural parasitism of this parasitoid were studied during 1982 and 1983 and the results are reported. The occurrence of *B. hebetor* as a natural parasitoid of *O. arenosella* from different tracts indicates its wide distribution and its potential in the natural suppression of the pest. The long life span, long oviposition period, high fecundity and host finding are the major attributes which make *B. hebetor* an important biological control agent of *O. arenosella* on coconut.

**825. SELVASEKERAN, E. and CHANDRASEKERAN, B. 1984.** Black headed caterpillar menace in coconut. *Indian Cocon. J.* 15(7): 6–7. (Plant Clinic Centre, TNAU, Tirunelveli, T.N.).

A brief description on coconut black headed caterpillar (*Nephantis serinopa* Meyr.) is given. The biology of the pest, nature and extent of damage and control measures are described.

**826. SEN, N.L. and KAPADIA, M.N. 1985.** Effect of NPK fertilizers on the incidence of *Opisina arenosella* Wlk. (*Nephantis serinopa* Meyr.) on coconut palms. *Potash Rev. Subject 23*, (65th suite, no. 6). 3 p. (Plantation Crops Res. Station, GAU, Mahuva, Gujarat).

The study at Mahuva, Gujarat clearly indicates that a high rate of N (1.50 kg/palm) and P (0.75 kg/palm) increased the incidence of *O. arenosella* on coconut whereas high rate of K (1.75 kg/palm) increased the health and capacity for pest resistance.

827. SHAH, A.H.; JHALA, R.C.; PATEL, Z.P.; PATEL, G.M.; PATEL, B.M. and PATEL, C.B. 1988. Some new insect and mite pests of coconut recorded in Gujarat. *Indian Cocon. J.* 18(11): 13-14. (Dept. Entomology, N.M. College of Agric., GAU, Navasari, Gujarat).

A survey was conducted during 1983-85 for the insect and mite pests of coconut in Gujarat. Among the insects and mites collected, three insect and one mite species were found to be the first records from India. The new insect pests occurring were *Xyleborus perforans* (Scolytidae: Coleoptera), *Icerya formicarum* (Margarodidae: Homoptera) and *Aleurocanthus* sp. (Aleurodidae: Homoptera) and the new mite was *Oligonychus tyilus* (Tetranychidae: Prostigmata).

828. SHANTAPPA, P.B.; VISWANATH, B.A. and SULLADMATH, V.V. 1979. Red palm weevil *Rhynchophorus ferrugineus* from the inland plantations of Karnataka. *Curr. Res.* 8(2): 32. (Regional Coconut Res. Station, UAS, Arasikere, Karnataka).

*Rhynchophorus ferrugineus* a pest of coconut in coastal areas of Karnataka and Kerala, is reported from coconut plantations in inland areas of Karnataka. Recommended chemical control measures are described.

829. SINGH, K.G. 1982. Harmonisation and effectiveness of plant quarantine legislation and regional cooperation in Asean Region. In: International conference on Plant Protection in the Tropics, Mar. 1-4, 1982, Kuala Lumpur. Proceedings of conference. Edited by K.L. Heong and others. Kuala Lumpur: Malaysian Plant Protection Society. p. 647-658. (ASEAN Regional Plant Quarantine Centre & Training Institute, Serdang, West Malaysia).

The establishment of the ASEAN - Plant Quarantine Centre and Training Institute (PLANTI) to standardize plant quarantine legislation in South-East Asia and the Pacific Region

against plant pests and diseases is discussed. An annotated list is presented, showing the known distribution and pest or disease status, of numerous pests and diseases of coconut, cacao, cashew and other plantation crops and field crops.

830. SREEKUMAR, S. and PRABHU, V.K.K. 1988. Digestive enzyme secretion during metamorphosis in *Oryctes rhinoceros* (Coleoptera: Scarabaeidae). *Proc. Ind. Acad. Sci. (Anim. Sci.)* 97(1): 67-71. (Dept. of Zoology, Univ. of Kerala, Trivandrum, Kerala).

Protease, amylase, lipase and trehalase are present in the larval and adult midguts of *Oryctes rhinoceros*. The presence of trehalase in the pupal midgut suggests that food digestion is not the normal function of gut trehalase. Quantitative studies reveal that protease and amylase in the third instar larvae reach very low levels as the larvae become older and consume little or no food. These two enzymes are not measurable in the non-feeding prepupa and pupa and reappear in the adult with commencement of feeding. Secretion of digestive enzymes is correlated with feeding.

831. SREEKUMAR, S. and PRABHU, V.K.K. 1988. Probable endocrine role of midgut tissue in stimulation of digestive enzyme secretion in *Oryctes rhinoceros* (Coleoptera: Scarabaeidae). *Proc. Ind. Acad. Sci. (Anim. Sci.)* 97(1): 73-78. (Dept. of Zoology, Univ. of Kerala, Trivandrum, Kerala).

The effect of midgut epithelial extract on digestive enzyme secretion in the third instar larva of *Oryctes rhinoceros* was studied. Midguts dissected out from third instar larvae were cut at both ends, emptied of their contents, washed in insect saline, ligated at the open ends and incubated in a medium containing extract of 2 midgut epithelia/90 ml incubation solution. As control midgut preparations were incubated in insect saline without midgut epithelial extract. After 30 min of incubation, the contents of

the midgut preparations incubated with midgut epithelial extract showed increased secretion of protease and amylase when compared with controls. Digestive enzyme release into gut lumen appears to be due to the action of a hormone present in the midgut epithelium.

832. SUDHEENDRA KUMAR, V.V.; MOHAMMED, U.V.K.; ABDURAHIMAN, U.C. and NARENDRAN, T.C. 1978. Mating behaviour of *Bracon brevicornis* Wesmael (Hymenoptera: Braconidae): a larval parasite of *Nephantis serinopa* Meyrick, the black headed caterpillar of coconut. *Agric. Res. J. Kerala*, 16(2): 224–226. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

The pattern of mating and the behavioural aspects involved in host selection and host acceptance in the braconid parasitoid are briefly given.

833. SUDHEENDRA KUMAR, V.V.; MOHAMMED, U.V.K.; NARENDRAN, T.C. and ABDURAHIMAN, U.C. 1982. Biology and morphology of immature stages of *Bracon brevicornis* (Hymenoptera: Braconidae) an important biological control agent of the black headed caterpillar *N. serinopa*, a pest of coconut. *J. Bombay Nat. Hist. Soc.* 79(2): 254–260. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

*Bracon brevicornis* (Braconidae: Hymenoptera) is one of the important bio-control agents of *Nephantis serinopa*, the black headed caterpillar pest of coconut. An account of the biology and morphology of the immature stages of this parasitic wasp is given. There are five larval instars and the duration of development from egg to adult takes about 7–8.5 days.

834. SUDHEENDRA KUMAR, V.V.; REMADEVI, O.K.; MOHAMMED, U.V.K.; NARENDRAN, T.C. and ABDURAHIMAN, U.C. 1979. *Meteoridea hutsoni* (Nixon) (Braconidae: Hymenoptera), a new larval parasite of *Nephantis serinopa*

Meyrick (Xylorictidae: Lepidoptera). *Entomon* 4(3): 303–305. (Dept. of Zoology, Univ. of Calicut, Calicut, Kerala).

This is the first record of *Meteoridea hutsoni* (Nixon) from *N. serinopa* collected from Malabar.

835. SUMANGALA S. NAMBIAR 1988. Susceptibility of hybrid coconut varieties to *Oryctes rhinoceros* Linn. (Scarabaeidae) under rainfed conditions at Pilicode. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Nov. 23–26, 1988. Abstracts of papers. p.17. (RARS, KAU, Pilicode, Kerala).

With a view to study the fluctuations in the susceptibility of different coconut hybrids, observations on the percentage leaf damage due to beetle attack was recorded from a 13 year old hybrid coconut plantation at the Regional Agricultural Research Station, Pilicode, maintained under rainfed conditions during 1986–1988. Among the 16 hybrid combinations, CC x CDO was found to be the most susceptible (21.1%), followed by WCT x LO, AO x CDO and Fiji x CDO. The lowest damage was recorded by CDO x WCT (8%) followed by WCT x CDG and WCT x GB.

836. SUMANGALA S. NAMBIAR and JOY, P.J. 1988. Pest management in coconut. In: Six decades of coconut research. Edited by M. Aravindakshan. Trichur: Kerala Agricultural University. p.103–113. (RARS, KAU, Pilicode, Kerala).

Studies on pest management in coconut taken up by the Kerala Agricultural University were summarised in this chapter.

837. SUNDARARAJU, D. and ORLANDO, F. RODRIGUES. 1985. Survey on incidence of coconut leaf-eating caterpillar, *Opisina arenosella* Wlk. and its natural enemies in Goa. *Indian Cocon. J.* 16(3): 3–6. (ICAR Res. Complex for Goa, Ela, Old Goa, Goa).

A survey was carried out to assess the intensity of leaf eating caterpillar *Opisina arenosella* Wlk. and its natural enemies in Goa. Details on the methodology adopted in the survey and results are discussed.

**838. THAMMIRAJU, N.B.; RAO A. GANESWARA and LAXMINARAYANA, K.** 1979. *Mucialla rufivena* Walker (Pylalidae: Lepidoptera); a new inflorescence pest of coconut. *Indian Cocon J.* 10(2): 4–5. (Parasite Breeding Station, Ambajipet, A.P.).

Biology and life history were discussed. The pest completes its life cycle in 29–38 days.

**839. VEERESH, G.K.** 1983. Coconut root grubs and their control in Karnataka, India. In: Proceedings of the Coconut research and development, international symposium. *1st, Kasaragod, Dec. 27–31, 1976.* Edited by N.M. Nayar. New Delhi: Wiley Eastern. p.385–391. (Dept. of Entomology, UAS, Bangalore, Karantaka).

Three species of white grubs damage coconut in Karnataka. While *Leucopholis coneophora* Burm. and *L. lepidophora* Blanchard confine themselves to heavy rainfall areas of coastal Karnataka and Malnad, *Holotrichia serrata* Fabricius is endemic to the plains. Ecology and chemical control of *H. serrata* were studied. Five soil insecticides including chlordane 20 EC, dursban 200 EC, phorate 10 G, counter 5 G, and temik 10 G, were tried under irrigated and unirrigated conditions at two levels each. Dursban 200 EC at 10 ml, and counter 5 G and phorate 10 G, at 20 g/palm with irrigation after insecticide treatment gave good control of grubs.

**840. VENKATARAM, C.S.** 1980. Plant protection in plantation crops through the 80's *J. Plantn Crops* 8(1): 1–12. (UPASI, Scientific Dept., Cinchona, T.N.).

The author discusses the different as-

pects of plant protection in plantation crops in India in the 1980s. Special reference is made for protection through genetic manipulation and biological and chemical control measures. The main plantation crops covered are tea, coffee, pepper, cashew, cardamom, arecanut, coconut, rubber and cacao.

**841. VISALAKSHI, A.; BEEVI, S.N.; PILLAI, K.S.; NAIR, K.K.R. and DAS, N.M.** 1987. Control of the coreid bug pest on coconut. *Entomon* 12(4): 395–396. (College of Agric., KAU, Trivandrum, Kerala).

Three insecticides viz., carbaryl, HCH (both at 0.1 and 0.2%) and endosulfan (at 0.05 and 0.1%) were tested for the control of the coreid *Paradasynus rostratus* on coconuts in Kerala, in 1982–83. Effective control was achieved with 0.1% carbaryl, 0.2% HCH or 0.1% endosulfan.

**842. VISALAKSHI, A.; NAIR, K.K.R. and NALINAKUMARI, I.** 1982. *Lepidosaphes mcgregori* Banks, a new hard scale infesting coconut. *Entomon* 7(4): 500. (College of Agric. KAU, Trivandrum, Kerala).

The diaspidid scale *Lepidosaphes mcgregori* Banks was found infesting coconut leaves and fruits in Trivandrum district in Kerala, in 1981. This was the first record of the insect on coconut. It could be controlled by spraying with dimethoate at 0.05% or carbaryl at 0.02%.

**843. VYAS, H.N. and BUTANI, B.G.** 1986. Some studies on indigenous parasites of black headed caterpillar (*Nephantis serinopa* Meyrick) under Junagadh (Gujarat State) conditions. *Pesticides* 20(1): 21–22. (College of Agric., GAU, Junagadh, Gujarat).

The indigenous parasites of the xyloxyctid *Nephantis serinopa* (*Opisina arenosella*) a pest of coconut were identified from field collection of larvae and pupae of the pest, and parasite cocoons in Gujarat, India, in 1978–80. The

extent of field parasitism on *N. serinopa* by various larval and pupal parasites have been discussed.

44. YADAV, D.N. 1985. Influence of nectar on the fecundity, longevity and sex-ratio of *Bracon brevicornis* Wesm. an important parasite of *Opisina arenosella* Walk. the black headed caterpillar of coconut. *Curr. Sci.* 54(17): 877-878. (GAU, Anand, Gujarat).

A brief scientific note is presented on fecundity, longevity and sex ratio of *B. brevicornis* on different food sources. The food sources like pollen and nectar from perennial shrub called *Justicia jendurose* proved to be promi-

nent. *B. brevicornis* is a parasite on *O. arenosella*.

845. YADAV, D.N. and DHAMALIA, H.R. 1985. Natural enemies of *Opisina arenosella* Walk. the black headed caterpillar. *Indian Cocon. J.* 16(12): 9-10. (All India Research Project on Biological Control, GAU, Anand Campus, Anand, Gujarat).

A survey was carried out to select natural enemies of *O. arenosella* in Gujarat state of India. Eight species of parasites attacking the larval and pupal stages of *Opisina* were detected. Larva of the newly recorded *Chrysopa* sp. was observed preying on eggs of *O. arenosella*. Another two species found were Chalcidids and Ichneumonids.

846. DAREKAR, K. S. and KHAN, E. 1980. Two new species of *Helicotylenchus* Steiner (Tylenchidae: Nematoda) from Maharashtra, India. *Nematol. Medit.* 8 (1): 1-7. (Div. of Nematology, IARI, New Delhi 110 012).

Two new species of *Helicotylenchus* from Maharashtra, India are described: *H. morasii* sp. n. collected from the rhizosphere of *Sorghum vulgare* Pers. has rounded head with 5-6 annules and dorsally convex-conoid tail ending into subacrete unstriated terminus. *H. eletropicus* sp. n. collected from the rhizosphere of coconut, *Cocos nucifera* L. has conoid-truncated head with indistinct annules and convex-conoid tail with a blunt to sharply conoid terminal projection.

847. GOVINDANKUTTY, M.P. AND KOSHY, P.K. 1978. Nematodes associated with the coconut palm (*Cocos nucifera* L.). Working paper of FAO Plant Protection Committee for the South East Asia and Pacific Region, 11th Session, Kathmandu, Nepal Sep. 22-29, 1978. 31p. FAO Technical Document no. 126. (CPCRI (RS), Kayangulam, Kerala).

Plant parasitic nematodes are implicated as direct causative factors or vectors of pathogenic agents of certain diseases in coconut. An elaborate information on nematodes and their association in the coconut palm have been highlighted in the paper.

848. GRIFFITH, R. and KOSHY, P.K. 1990. Nematode parasites of coconut and other palms. In: Plant parasitic nematodes in subtropical and tropical agriculture. (Coconut Research, Ministry of Food Production, Marine Exploitation, Central Experiment Station, Centeno, via Arima, P.O. Trinidad, West Indies).

The history, distribution, symptoms,

transmission and environmental factors affecting red ring disease of coconut; biology, host range, control and methods of diagnosis of *Rhadinaphelenchus cocophilus* causing red ring disease; biology, host range and control method of *Radopholus similis*, an important nematode attacking coconut and arecanut are given. Nematodes attacking date palm have not been well studied with the exception of *Meloidogyne* spp.

849. HABEEBULLAH, B.; REGUPATHY, A.; RETHINAM, P. and KOSHY, P.K. 1979. Residues of Aldicarb in coconut. In: Pesticides and Environment seminar, TNAU, Coimbatore. Proceedings of seminar. p.73-74. (Pesticide Residue Laboratory, Dept. of Agricul. Entomology, TNAU, Coimbatore-641 003, T.N.).

Aldicarb 10 G was applied at 10 and 50 g a.i./palm twice at monthly interval. In another experiment aldicarb was applied at 10 g a.i./palm once. Aldicarb applied twice resulted in the accumulation of residues to the extent of 0.07 to 0.38 ppm even 70 days after second round. The accumulation of residues was more in copra than in coconut water. Aldicarb when applied once at 10 g a.i./palm resulted in the residue level 0.02 to 0.12 ppm when harvested 40-90 days after application.

850. KHAN, E.; AZMI, M.I. and CHAWLA, M.L. 1977. *Yubeldus glandulosus* gen. n., sp. n. (Belondiridae: Nematoda) from Bangalore, India. *Indian J. Nematol.* 7:186-188. (Div. of Nematology, IARI, New Delhi 110 012).

*Yubeldus glandulosus* gen. n., sp. n., obtained from soil around roots of coconut palm in Lalbagh, Bangalore, India, could not be accommodated under any of the nominal genera of Belondiridae. It is distinctive by having an offset head, large hypodermal glands,

oesophageal bulb is covered by a spiral muscular sheath and not separated from anterior portion of oesophagus by constriction. Female reproductive system amphidelphic and tail rounded, slightly swollen.

851. KOSHY, P.K. and RADHAKRISHNAN NAIR, C.P. 1979. Control of *Radopholus similis* (Cobb; 1893) Thorne 1949 in coconut nursery. *Indian J. Nematol.* 9:15-19. (CPCRI (RS), Kayangulam, Kerala).

To prevent the spread of *Radopholus similis* to uninfested areas through infested coconut seedlings, nursery beds at Central Plantation Crops Research Institute, Kasaragod were treated with fensulfothion @ 50 kg a.i./ha, carbofuran @ 6 kg a.i./ha and DBCP @ 60 l a.i./ha, three times in a year. Though none of the treatments was effective in complete eradication of the nematode; fensulfothion reduced root population to the maximum extent followed by DBCP and carbofuran.

852. KOSHY, P.K. and SOSAMMA, V.K. 1977. Identification of the physiological race of *Radopholus similis* population infesting coconut, arecanut and banana in Kerala, South India. *Indian Phytopath.* 30(3):415-416. (CPCRI (RS), Kayangulam, Kerala).

Experiments with citrus spp. *trifoliata* orange and banana seedlings indicated that the *Radopholus* population attacking coconut, arecanut & banana belonged to the "banana race".

853. KOSHY, P.K. and SOSAMMA, V.K. 1978. A handy tool for coconut research. *Indian Cocon. J.* 9(7): 4-5. (CPCRI (RS), Kayangulam, Kerala).

Large size of seednut and seedling always make difficulty in green house experiments. To avoid this a new technique is developed. Seednuts were dehusked retaining a tuft of fibres covering the eyes of the nut and sown in steam sterilized soil contained in 35 cm

earthen pots or in thick polythene bags of 45 x 30 cm and kept on green house benches and watered regularly. The nuts germinated within 75 to 90 days from the date of harvest, thus avoiding the delay in normal germination which took 135 to 150 days. Availability of uninjured roots is another advantage of this method. Sprouts raised as above can be used for various nematological studies.

854. KOSHY, P.K. and SOSAMMA, V.K. 1978. Studies on the population fluctuations of *Radopholus similis* in coconut and arecanut roots. *Indian Phytopath.* 31(2):180-185 (CPCRI, (RS), Kayangulam, Kerala).

Population of *Radopholus similis* in coconut and arecanut roots were found to fluctuate between samples, palms, months and years. Highest populations were recorded during October-November and lowest or nil during May-July. Though temperature, rainfall and availability of susceptible roots play their own roles in the population build-up temperature was found to have a more decisive effect than others.

855. KOSHY, P.K. and SOSAMMA, V.K. 1978. Susceptibility of coconut plumule to *Radopholus similis*. *Indian J. Nematol.* 8(1):77-78. (CPCRI (RS), Kayangulam, Kerala).

In laboratory experiments, it is observed that *R. similis* produced reddish-brown lesions on coconut plumules and reproduced in the tissues.

856. KOSHY, P.K. and SOSAMMA, V.K. 1979. Control of the burrowing nematode, *Radopholus similis* on coconut seedlings with DBCP. *Indian J. Nematol.* 9:32-33. (CPCRI (RS), Kayangulam, Kerala).

West Coast Tall coconut seedlings infested with *Radopholus similis* were given a dip treatment with 250, 500 or 1000 ppm DBCP for 5, 10, 15, or 30 min. Treatment with 1000

extent of field parasitism on *N. serinopa* by various larval and pupal parasites have been discussed.

844. YADAV, D.N. 1985.\* Influence of nectar on the fecundity, longevity and sex-ratio of *Bracon brevicornis* Wesm. an important parasite of *Opisina arenosella* Walk. the black headed caterpillar of coconut. *Curr. Sci.* 54(17): 877-878. (GAU, Anand, Gujarat).

A brief scientific note is presented on fecundity, longevity and sex ratio of *B. brevicornis* on different food sources. The food sources like pollen and nectar from perennial shrub called *Justicia jendurose* proved to be promi-

nent. *B. brevicornis* is a parasite on *O. arenosella*.

845. YADAV, D.N. and DHAMALIA, H.R. 1985. Natural enemies of *Opisina arenosella* Walk. the black headed caterpillar. *Indian Cocon. J.* 16(12): 9-10. (All India Research Project on Biological Control, GAU, Anand Campus, Anand, Gujarat).

A survey was carried out to select natural enemies of *O. arenosella* in Gujarat state of India. Eight species of parasites attacking the larval and pupal stages of *Opisina* were detected. Larva of the newly recorded *Chrysopa* sp. was observed preying on eggs of *O. arenosella*. Another two species found were Chalcidids and Ichneumonids.

ppm for 15 min. or longer killed all the nematodes in roots inside the husk. Phytotoxicity was observed if concentrations of 1000 ppm were used for 30, 45 or 60 min. Treatment with 1000 ppm DBCP for 15 min. also killed nematodes on the roots outside the husk.

857. KOSHY, P.K. and SOSAMMA, V.K. 1982. A simple method for inoculation and production of symptoms by *Radopholus similis* on coconut. *Indian J. Nematol.* 12:200-203. (CPCRI (RS), Kayangulam, Kerala).

Raising sprouts of coconuts by dehusking seednuts retaining a tuft of fibers covering the eyes of the nut was found to accelerate germination and make roots available six weeks earlier for easy handling in the laboratory. Using this method typical elongate orange coloured lesions can be detected on coconut roots after 24 hours of inoculation with *R. similis*.

858. KOSHY, P.K. and SOSAMMA, V.K. 1982. Culturing of *Radopholus similis* within mesocarp of coconut. *Pl. Dis.* 66(9):811. (CPCRI (RS), Kayangulam, Kerala).

A method of culturing *Radopholus similis* within the mesocarp of coconut is described. The method can be used for quick varietal screening of coconut.

859. KOSHY, P.K. and SOSAMMA, V.K. 1987. Pathogenicity of *Radopholus similis* on coconut (*Cocos nucifera* L.) seedlings under green house and field conditions. *Indian J. Nematol.* 17:108-112. (CPCRI (RS), Kayangulam, Kerala).

Pathogenicity of *R. similis* on potted (35 cm) coconut seedlings was studied under green house conditions. The different levels of axenic populations were 0, 100, 1000, 10,000 and 100,000 nematodes per plant and the fungus *Cylindrocarpon effusum* alone and in combination with nematode. In general, reduced growth of plants and intensity of root lesions and rotting were directly proportional to the

increase in nematode population. An inoculum level of 100,000 nematodes was found to cause 40, 55, 20, 65, 71, 48 and 52 per cent reduction over control plants whereas with 100 nematodes it was only 11, 28, 15, 31, 41, 26 and 27 per cent reduction over control with respect to height, shoot weight, number of leaves, leaf area, number of lateral roots, volume and weight of root over a period of one year.

860. KOSHY, P.K.; SOSAMMA, V.K. and PREMCHANDRAN, D. 1977. Nematodes associated with coconut. *Indian Cocon. J.* 8(3):1-2. (CPCRI (RS), Kayangulam, Kerala).

A general description of nematodes with life cycle and their feeding habits described. General description of red ring disease caused by *Rhadinaphalenches cocophilus* is also presented. Twenty three genera of plant parasitic nematodes were identified at the CPCRI, Regional Station, Kayangulam and the most important of these was *Radopholus similis* responsible for root-rotting. Preventive measures are described in controlling the spread of this nematode.

861. KOSHY, P.K.; SOSAMMA, V.K. and RADHAKRISHNAN NAIR, C.P. 1975. Preliminary studies on *Radopholus similis* (Cobb, 1893, Thorne, 1949) infecting coconut and arecanut palms in South India. *Indian J. Nematol.* 5(1):26-35. (CPCRI (RS), Kayangulam, Kerala).

*R. similis* infestation on coconut and arecanut was reported from various districts of Kerala, Karnataka and Tamil Nadu. The semi-hard orange-coloured portion of the main roots of coconut harbours the highest number of nematodes. Peeling and slicing of roots during processing resulted in maximum nematode recovery. Optimum temperature range for extraction of *R. similis* from coconut roots is 4.0-14.0°C. *R. similis* produced small elongated reddish brown cortical lesions on roots of coconut and arecanut which later coalesce and

cause extensive root rotting. Populations from coconut, arecanut and banana did not differ in their pathogenicity. The coconut cultivars viz., West Coast Tall, Dwarf Orange, Dwarf Green, Gangabondam, Tall x Dwarf, Dwarf x Tall and Tall x Gangabondam were susceptible to the burrowing nematode.

862. KOSHY, P.K.; SOSAMMA, V.K. and SUNDARARAJU, P. 1980. Survey of plant parasitic nematodes of coconut in India. In: Symposium on Plantation Crops, 2nd, UPASI, Ootacamund, Jun. 26-29, 1979. Proceedings of PLACROSYM II. Edited by C.S. Venkataram and others. p.45-49. (CPCRI (RS), Kayangulam, Kerala).

Observation of 210 soil samples from the root zones of coconut collected from various locations, yielded 29 genera of plant parasitic nematodes. *Radopholus similis* population was frequently met within the roots showing lesions. Infested roots exhibited elongate reddish brown lesions and various intensities of rotting. A maximum number of 745 *R. similis* /g of root was observed during the survey. Highest population occurred during September to November and the least during April to June. Extraction of *R. similis* under lower temperature conditions (10-20°C) in a refrigerator or BOD incubator was found to yield more nematodes from infested roots.

863. KOSHY, P.K.; SUNDARARAJU, P. and SOSAMMA, V.K. 1978. Occurrence and distribution of *Radopholus similis*. (Cobb, 1893) Thorne, 1949 in South India. *Indian J. Nematol.* 8(1): 49-58. (CPCRI (RS), Kayangulam, Kerala).

Burrowing nematode, *Radopholus similis* is widely distributed in South India associated with coconut, arecanut, banana and pepper. In coconut plantations *R. similis* occurred maximum in sandy-loam soil. Banana as an intercrop was found to favour multiplication of *R. similis* in arecanut gardens. A range of

10-20°C was the optimum temperature for extraction of active *R. similis* population from banana and pepper roots. The introduction of *R. similis* in a new area through infested coconut seedlings recorded here, warrants the need for immediate intra and inter state regulatory measures against distribution of nematode infested planting materials.

864. KOSHY, P.K.; SUNDARARAJU, P. and SOSAMMA, V.K. 1980. Burrowing nematode *Radopholus similis*, a potential threat to Indian agriculture. *Indian Fmg* 29:1-2(CPCRI (RS), Kayangulam, Kerala).

The burrowing nematode, *R. similis* is notorious as the cause of spreading decline of citrus in Florida, pepperyellows in the Bangka island of Indonesia and root and rhizome rot of banana in all banana growing tracts of the world except in Taiwan and Israel. In India, no data is available on loss due to the infestation of this nematode on any crop, though the nematode was recorded in 1966 and known to parasitize several crops. This nematode causes lesions and rotting on roots in banana and coconut and root rotting in pepper. A dip treatment in 1000 ppm DBCP for 15 minutes is recommended for nematode free coconut seedlings.

865. KOSHY, P.K.; SUNDARARAJU, P.; SOSAMMA, V.K. and RAVIKUMAR, K. 1985. Efficacy of four systemic nematicides against *Radopholus similis* in coconut nursery. *Indian J. Nematol.* 15(2):148-151. (CPCRI (RS), Kayangulam, Kerala).

Aldicarb, carbofuran, phorate and phenamiphos (fenamiphos) at 10, 15 and 25 kg a.i./ha, applied 3 times at the same rate for one year were evaluated for the control of *R. similis* in coconut nurseries. All treated plants showed an increase in growth with aldicarb giving the best plant growth. Except 10 kg a.i./ha of aldicarb and 10 and 25 kg

a.i/ha of carbofuran, all dosages and nematicides reduced nematode populations. Complete control of *R. similis* was obtained with phenamiphos/phorate at 25 kg a.i/ha.

866. SINGH, K.P.; PANDEY, S.Y.; KHAN, M.M. and SINGH, SATYENDRA. 1983. Residues of aldicarb in coconut. *Pestic. Sci.* 14(4):441-443. (Research and Development Centre, Union Carbide India Limited, Bhopal, M.P.).

Tender and mature nuts from healthy and *Radopholus similis* infested palms, treated with granulated aldicarb at 0.5-1.0 kg/ha, were sampled 45 and 90-105 days after treatment. At 45 days after treatment the aldicarb residues in kernels did not exceed 0.04 mg/kg and in milk samples no detectable residues were found.

867. SOSAMMA, V.K. 1984. "Studies on the burrowing nematode of coconut". Ph.D. thesis. University of Kerala, Trivandrum. 166 p. (CPCRI (RS), Kayangulam, Kerala).

Investigations on the distribution, host range, effect of various soil types and population fluctuation of *Radopholus similis* infesting coconut palm have been carried out. The thesis also contains details of studies carried out on the pathogenicity of the nematode on coconut, its association with fungal organisms, reaction of coconut cultivars to the nematode and a nematicidal treatment to control the nematode in coconut.

868. SOSAMMA, V.K. and KOSHY, P.K. 1977. Additional hosts of burrowing nematode, *Radopholus similis*, infesting coconut palm in South India. *Pl. Dis. Repr* 61(9):760-761. (CPCRI (RS), Kayangulam, Kerala).

The host status of twenty-four species from sixteen plant families was tested against *Radopholus similis*. *Adenanthera pavonia*, *Tamarindus indica*, *Vicia faba*, *Careya arborea*, *Lagenaria vulgaris*, *Cucurbita pepo*, *Trichosanthes angulina religiosa* and *Phoenix dactylifera* were

recorded as hosts for *R. similis*. Except for *Cucurbita pepo*, all were new host records for *R. similis*.

869. SOSAMMA, V.K. and KOSHY, P.K. 1978. A note on the association of *Cylindrocarpon effusum* and *C. lucidium* with *Radopholus similis* in coconut. *Indian Phytopath.* 31(3): 381-382. (CPCRI (RS), Kayangulam, Kerala).

*Cylindrocarpon effusum* and *C. lucidium* could be isolated from the lesions on roots of coconut in association with *R. similis*.

870. SOSAMMA, V.K. and KOSHY, P.K. 1981. Other host records of *Radopholus similis* infecting coconut palm in South India. *Indian J. Nematol.* 11:73-74. (CPCRI (RS), Kayangulam, Kerala).

Eighteen plant species were screened for infestation with *R. similis* in 10 cm earthen pots during August, 1978 and 1979. The inoculum level used was 500 active specimens (female and larvae) suspended in 10 ml of water. Observations were recorded after 4 months. Among the 18 plant species tested, nine were recorded as hosts. Except for *Erythrina lithosperma* and *Daucus carota* all were new host records for *R. similis*.

871. SOSAMMA, V.K. and KOSHY, P.K. 1983. A note on the occurrence of *Cylindrocladium clavatum* Hodges and May in lesions caused by *Radopholus similis* on coconut roots. *Curr. Sci.* 52(9):438. (CPCRI (RS), Kayangulam, Kerala).

Association of the fungus *Cylindrocladium* sp. with coconut palm and its relationship to *R. similis* are described.

872. SOSAMMA, V.K. and KOSHY, P.K. 1985. The survival of *Radopholus similis* infesting coconut in host free soil (abstract). In: Nematology Symposium, Udaipur, May 17-18, 1985. Proceedings of symposium. p.106. (CPCRI (RS), Kayangulam, Kerala).

The burrowing nematode *Radopholus similis* population survived in air dried soil for a period of 3 months. Under moist conditions active nematode populations could be recovered upto 15 months.

873. SOSAMMA, V.K. and KOSHY, P.K. 1985. Effect of different types of soils on multiplication of *Radopholus similis* and growth of coconut seedlings. *Indian J. Nematol.* 15(2):217-222. (CPCRI (RS), Kayangulam, Kerala).

The influence of different soil types viz. laterite, riverine alluvium, coastal alluvium (coastal sand), loamy sand and reclaimed marshy or 'Kari' soil on multiplication of *Radopholus similis* and growth of coconut seedlings was studied. Best growth of uninoculated seedlings was recorded in riverine alluvium followed by the laterite soil. Plant growth was poor in reclaimed marshy soil with maximum per cent clay, silt and a minimum of coarse sand with a pH of 4.1. In inoculated plants the maximum plant damage was recorded in riverine alluvium followed by loamy sand and coastal sand and the least in laterite soil. Maximum nematode multiplication was obtained from loamy sand followed by riverine alluvium and the least in 'Kari' soil.

874. SOSAMMA, V.K.; KOSHY, P.K. and RAO, E.V.V. BHASKARA. 1988. Response of coconut cultivars to the burrowing nematode, *Radopholus similis*. *Indian J. Nematol.* 18(1): 136-137. (CPCRI (RS), Kayangulam, Kerala).

Twenty four coconut cultivars were screened against *R. similis* under field conditions. The root lesion index had no direct correlation with the population per gram of root. Therefore, it was considered safe to classify a cultivar as tolerant or less susceptible only when both root lesion index as well as population per gram were reduced. On this basis, Java

Tall (from Indonesia), Klapawangi (from Malaysia) and Andaman Giant and Kenthali (from India) were considered fairly tolerant to *R. similis*. Java Tall alone or in hybrid combinations with Malayan Dwarf Yellow were recommended for cultivation in *R. similis* infested areas.

875. SUNDARARAJU, P. 1977. Nematodes associated with coconut. *Kisan Wld* 5:57-58. (CPCRI (RS), Kayangulam, Kerala).

The most important nematode disease of coconut is the "red ring" disease of coconut caused by *Radinaphelenchus cocophilus* which is known to occur in most of the Caribbean islands, Brazil and San Salvador. This nematode is not reported from India. Of the coconut nematodes reported from India, *Radopholus similis* is the most important one causing lesions and rotting on roots.

876. SUNDARARAJU, P. 1981. Nematodes associated with fodder crops in a coconut garden (abstract). In: *Nematology Symposium, TNAU, Coimbatore, Feb. 13-15, 1981.* Abstracts of papers. p.116-117. (CPCRI (RS), Kayangulam, Kerala).

The study was conducted to find out the effect of various fodder crops such as stylo (*Stylosanthus gracilis*), Pusa Giant Napier, NB-21, and Guinea grass on the population build up of nematode fauna. These crops were found to have no significant effect on the population build up of nematodes on coconut. *Radopholus similis* was recorded only from coconut roots whereas *Pratylenchus seae* was recorded from roots of all fodder crops but not from coconut. *Tylenchorhynchus coffeae* was occasionally recorded from coconut roots. Fourteen species of nematodes were recorded from the fodder crops.

### 10.3 Mites and Other Arthropodes

877. DAVIS, T.A. 1987. Observations on the coconut robber crab (*Birgus latro*). *Indian Cocon. J.* 18(7):3-12. (JBS Haldane Res. Centre, Nagercoil, T. N.).

The giant coconut robber crab (*Birgus latro*) is distributed in the Pacific and Indian Ocean Islands. In Andaman islands, *B. latro* is seen in any appreciable number only in South Sentinel island. It survives in this island because man has not exploited it for fear of dangerous tribals. Very little is known to the crab's behaviour and biology. Are they serious pests of coconut and can they dehusk and break open whole coconuts to eat the kernel? are the controversial questions that require convincing answers.

878. DAVIS, T.A. and ALTEVOGT, RUDOLF. 1978. Is the coconut crab a pest of coconut? *Wild Crops* 30(4):157-162, 172. (JBS Haldane Res. Centre, Nagercoil, T.N.).

The robber crab, *Birgus latro* is diurnal in South Sentinel island. Large number of this crab was studied in this island during 1973 and 1974. In islands of the Pacific where human and other predators abound, the crab has become nocturnal. Even in Greater Nicobar the crab is mostly nocturnal. An account of the reported association of the crab with the coconut palm is given based on fresh data obtained during the Indo-West German expeditions to the South Sentinel.

879. JALALUDDIN, MOHAMED, S. and MOHANASUNDARAM, M. 1990. Control of coconut red mite *Raoiella indica* Hirst (Tenuipalpidae: Acari) in the nursery. *Indian Cocon. J.* 21(6):7-8. (TNAU, Coimbatore, T.N.).

The toxicity of seven pesticides to *Raoiella indica* Hirst on coconut nursery was determined in field test in Tamil Nadu, India as judged

by the number of live mites. After fourteen days of spraying monocrotophos 0.04% or dimethoate 0.03% or phosphamidon 0.05% or methomyl 0.025% gave significantly better control than other treatments.

880. MOHANASUNDARAM, M. and KARUPPACHAMY, P. 1989. A review of mites attacking coconut in Tamil Nadu. *Indian Cocon. J.* 20(5):9-13. (Dept. of Entomology, TNAU, Coimbatore, T.N.).

Presents a list of mites attacking coconut of the world and those recorded in Tamil Nadu. Types of damage caused by these mites and their present economic status were studied. Brief description of the mites for field identification and their economic status as pests or vectors of virus diseases are also given.

881. MOHANASUNDARAM, M.; NATARAJAN, K. and RAMASUBRAMANIAN, G.V. 1989. Record of a new tenuipalpid mite, *Dolichotetranychus* sp. (Tenuipalpidae:Acari) on coconut buttons in Tamil Nadu and its significance. *Indian Cocon. J.* 20(5):17. (Dept. of Entomology, TNAU, Coimbatore, T.N.).

A new species of *Dolichotetranychus* has been discovered under the perianth of young coconut buttons and developing fruits. This has been found to cause button shedding and this is the first record of tenuipalpid mite on fruits.

882. RAO, P. RAMA MOHAN; RAO, A. GANESWARA and LAXMINARAYANA, K. 1977. New record of predatory spiders of coconut black headed caterpillar, *Nephantis serinopa* Meyrick in Andhra Pradesh. *J. Res. Andhra Pradesh Agric. Univ.* 4(1-4):58. (Agric. Res. Station, Ambajipeta, A.P.).

Four predatory spider species on *N. serinopa* were observed during a survey of coconut gardens in East Godavari district of Andhra Pradesh in 1976–77. They are *Chiracanthium melanostomata* Thorrel (Clubionidae), *Olios lamarcki* Latreille (Sparassidae), *Heteropoda leprosa* Simon (Heteropidae) and *Marpissa calcutaensis* Tikader (Salticidae).

**883. SARKAR, P.K. and SOMCHOUDHURY, A.K.** 1988. Evaluation of some pesticides against *Raoiella indica* Hirst on coconut palm in West Bengal. *Pesticides* 22(10):21–22. (Faculty of Agric., BCKVV, Kalyani, Nadia, W.B.).

Quinalphos, endosulfan, dicofol, ethion, monocrotophos (at 0.03 and 0.05%) and cypermethrin (at 0.009 and 0.01%) were tested against the tenuipalpid *Raoiella indica* on coconuts in West Bengal, India, during July, 1984. Monocrotophos was the most effective (causing 76.39% mortality), followed by dicofol (69.22%), quinalphos (60.26%), endosulfan (57.95%), ethion (45.57%) and cypermethrin (32.51%).

**884. SARKAR, P.K. and SOMCHOUDHURY, A.K.** 1989. Interrelationship between plant characters and incidence of *Raoiella indica* Hirst on coconut. *Indian J. of Ent.* 51(1):45–50. (Dept. of Agric. Entomology, Faculty of Agric., BCKVV, Kalyani, Nadia, W.B.).

Significant differences in morphological characters of coconut leaflets (length, width, thickness, depth of midrib groove and inter-vein distance) were found between 8 varieties, but no relationship was found between these characters, singly or in combination, and the rate of infestation by *Raoiella indica*. With regard to the chemical composition of the leaves (nitrogen, crude protein, moisture, calcium and phosphorus), all except the last 2 differed significantly among the 8 varieties and showed a positive correlation with the population build-up of *R. indica*.

**885. SATHIAMMA, B.** 1985. Record of *Dolichotetranychus vandergooti* (Oudemans) (Acarina: Tenuipalpidae) – a perianth mite on coconut. *J. Plantn Crops* 13(1): 73–75. (CPCRI (RS), Kayangulam, Kerala).

The mite *Dolichotetranychus vandergooti* was recorded as a new pest of coconut in Kerala in 1978. Details are given on its biology. Observations in 1978–79 showed that 95 of 116 nuts (79.83%) were infested by the mite. Spraying with 0.05% dimethoate every fortnight for a period of three months resulted in almost complete elimination of the mite population.

**886. SATHIAMMA, B.** 1986. *Oligonychus iseilemae* (Hirst) and observations on a red spider mite *Tetranychus* sp. on coconut foliage. *J. Plantn Crops* 14(1):71–73. (CPCRI (RS), Kayangulam, Kerala).

Notes on the habitat, distribution, host plants, life cycle and seasonal abundance of *Oligonychus iseilemae* Hirst and general observation on a red spider mite *Tetranychus* sp. on coconut foliage are given in this paper.

**887. SATHIAMMA, B.** 1988. Record of the red spider mite *Tetranychus ludeni* Zacher (Acarina: Tetranychidae) on the coconut palm. *Entomon* 12(2): 191–192. (CPCRI (RS), Kayangulam, Kerala).

*Tetranychus ludeni* is recorded from coconut palm foliage in India for the first time. In the laboratory, development from egg to adult was completed in 8–11 days. The longevity of female adults was 6.27 days, compared with 3.14 days for males. Fecundity varied from 6 to 13 eggs/female during an oviposition period of 5–9 days. In the field, the population peaked during January and February and was absent during June and July.

**888. SATHIAMMA, B.; JAYAPAL, S.P. and PILLAI, G.B.** 1987. Observations on spiders (Order:

Araneae) predacious on the coconut leaf eating caterpillar *Opisina arenosella* Wlk. (*Nephantis serinopa* Meyrick) in Kerala: feeding potential. *Entomon* 12(1):45-47. (CPCRI (RS), Kayangulam, Kerala).

Spiders of 18 species were collected from coconut plantations in Kerala, that were infested with the xyloryctid *Opisina arenosella* and kept individually with known numbers of larvae of *O. arenosella*, exceeding their needs. *Sparassus* sp., *Cheiracanthium* sp., *Rhene khandalaensis* and *R. indicus* were the most voracious, consuming 0.7-1.5 larvae/day.

889. SOMCHOUDHURY, A.K. and SARKAR, P.K. 1989. Observations on natural enemies found in association with coconut mite, *Raoiella indica*

Hirst. *Bull. Entomol.* 28(2):104-107. (Dept. of Agric. Entomology, Faculty of Agric., BCKVV, Kalyani, Nadia, W.B.).

The natural enemy complex of the coconut pest *Raoiella indica* was studied in West Bengal, India. The dominant predator was the staphylinid *Oligota* sp., followed by the predatory mites *Phytoseius* sp. and *Amblyseius* sp. The former 2 species showed a positive correlation with the population buildup of the pest, while the latter species was negatively correlated. The peak populations of *Oligota* sp. and *Phytoseius* sp. were recorded in June and September, coinciding with peak population of *R. indica*. A role of predators in the natural control of the pest is discussed.

branches (65%) and *M. booduga*, *Tatera indica* and *Suncus murinus* were ground dwellers. *Vandeleuria oleracea*, *Funambulus tristriatus*, *R. r. wroughtoni* and *R.r. rufescens* were primarily arboreal but were also active on the ground.

894. BHAT, S. KESHAVA and SUJATHA, A. 1987. Relative efficiency of two 'live' traps in capturing small mammals in coconut-cocoa mixed habitat. *J. Plantn Crops*. 15(2): 140-142. (CPCRI, Kasaragod, Kerala).

The effectiveness of wooden and Sherman 'live' traps in sampling small mammals was studied in five coconut-cocoa mixed gardens. The wooden traps captured significantly more number of *Rattus rattus wroughtoni* and *R.r. rufescens* whereas Sherman traps captured significantly more number of *Mus booduga* and *Suncus murinus*. *Funambulus tristriatus* and *Vandeleuria oleracea* did not show any specific preferences between the wooden and the Sherman traps.

895. BHAT, S. KESHAVA and SUJATHA, A. 1988. Effect of saturation baiting using multiple dose anticoagulants on the population of black rat in coconut fields. *Indian Cocon. J.* 18(9): 1-4. (CPCRI, Kasaragod, Kerala).

One time and two times baiting with multiple dose anticoagulants have reduced the population of black rats by 50% and 70% respectively. Continuous baiting for 3 times has reduced the population by 94% and damage by cent per cent. The cost involved for 3 times baiting was not much when compared to the returns from the operation.

896. BHAT, S. KESHAVA and SUJATHA, A. 1989. Laboratory evaluation of two anticoagulants against *Rattus rattus wroughtoni* Hinton. *J. Plantn Crops* 16(Suppl.): 217-221. (CPCRI, Kasaragod, Kerala).

Warfarin and fumarin are the two anticoagulant rodenticides available in India for

rodent control operations. The toxicity and relative acceptability of these poisons to the black rat, *Rattus rattus wroughtoni* Hinton, an important rodent pest of coconut and cocoa in South India were evaluated in the laboratory. There was no significant difference in the toxicity between these poisons (LFP<sub>50</sub> around 4 days for both the poisons) to *R.r. wroughtoni*, but there was much difference in their acceptance. After consuming the poison baits, the animals started dying from the third day onwards. The peak mortality was on the fifth day for warfarin and the seventh day for fumarin. Cent per cent mortality was achieved within 12 to 14 days feeding. However, the baits mixed with fumarin were preferred significantly to those mixed with warfarin and hence recommended to use such poison bait continuously for two weeks in the field.

897. BHAT, S. KESHAVA and SUJATHA, A. 1989. Prevent rat damage to tender coconut by bromadiolone baits. *Indian Cocon. J.* 20(7): 3-5. (CPCRI, Kasaragod, Kerala).

Damage to tender coconuts by black rat (*Rattus rattus*) in India is reported to range from 9-15% in Andhra Pradesh to 35 and 50% in Andaman and Lakshadweep islands, respectively. The species nests in the palms and rarely comes down to the ground for foraging. Damage other than to tender nuts is also described, and control measures are outlined. Baiting twice at 12-days intervals with 10-g bromadiolone wax cakes placed in the crown, on every fifth palm gave good control of the pest.

898. BHAT, S. KESHAVA and SUJATHA, A. 1989. Relative acceptance of different baits by *Rattus rattus wroughtoni* Hinton. *J. Plantn Crops*. 17(2): 121-137. (CPCRI, Kasaragod, Kerala).

The bait preferences of *R.r. wroughtoni* were studied using commonly available baits and baits with additives. It was observed that

the split forms of raw rice mixed with 2% sugar/jaggery was the best bait to mix poison for the control of this pest.

899. BHAT, S. KESHAVA and SUJATHA, A. 1991. Toxicity and field efficacy of bromadiolone against *Rattus rattus wroughtoni* Hinton. *J. Plantn Crops* 18(Suppl.): 285-290. (CPCRI, Kasaragod, Kerala).

The LD<sub>50</sub> value with 95% confidence limits of this poison, bromadiolone to *R.r. wroughtoni* was found to be 0.51 mg/kg body weight. One and two days exposure of rats to this poison resulted in 93% and 100% mortality, respectively. In coconut fields application of 10g bromadiolone baits, 2 times, at an interval of 12 days on the crown of every fifth palm completely reduced the rat damage.

900. BHAT, S. KESHAVA; SUJATHA, A.; ADVANI, RANJAN and SUKUMARAN, A.S. 1987. Population structure and breeding season in *Rattus rattus wroughtoni* Hinton. *Proc. Indian Acad. Sci. (Ani. Sci.)* 96(6): 657-665. (CPCRI, Kasaragod, Kerala).

Observations were made from July 82 to June 85 on certain aspects of population ecology of *R.r. wroughtoni*. Altogether 2639 specimens were collected. Male to female ratio was 0.87:1.0. Male rats were significantly heavier and bigger than the females. Pregnant female rats were encountered throughout the year with two peaks, one during early summer (Feb-March) and the other during monsoon (July-Aug.). The litter size ranged from 1-8.

901. GURUPRASAD, B.K. and SRIHARI, K. 1983. Rat damage and its control in coconut groves. In: Coconut research and development; proceedings of the international symposium, 1st, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.393-397. (Dept. of Zoology, UAS, GKVK Campus, Bangalore, Karnataka).

*Bandicota bengalensis* damages coconut seedlings by eating the roots and gnawing into the husk and shells, while *Rattus rattus* damages the nuts on the palms. Observations revealed that trunk banding alone does not control rat damage; on the other hand, it may even confine rats to particular palms. Such rats cause more damage than the rats on unbanded palms. Isolated rats could be successfully controlled by zinc phosphide treatment. Trunk banding followed by poison baiting effectively controlled *R. rattus*. Control of *B. bengalensis* in nurseries with zinc phosphide baiting followed by fumigation with aluminium phosphide proved efficient and profitable.

902. KRISHNAMOORTHY, B. 1983. Rodent problem in Lakshadweep. *Indian Cocon. J.* 13(11): 3-4. (ICAR Res. Complex (CPCRI), Minicoy, Lakshadweep).

Rat is a serious pest of coconut in Lakshadweep islands causing crop loss. The article outlines the nature of damage by rats and suitable control measures. The importance of educating the farmers with training on control is stressed.

903. KURIAN, CHANDY; NATARAJAN, P. and KOYA, ABDULLA, K.M. 1977. Efficacy of two indigenous traps for trapping rodents in a coconut plantation. *J. Plantn Crops* 5(2): 71-74. (CPCRI (RS), Kayangulam, Kerala).

The effectiveness of two rat traps, bamboo snap back-cum-noose trap and plank trap/death fall trap, was tested in a coconut plantation (23.5 ha area) for 24 months and 9 months respectively. The former gave 15.5% catch of *Bandicota bengalensis* and the latter gave 24.6% catch of *B. indica*, *Rattus rattus* and *Tatera indica*.

904. MATHAI, G. 1978. Rats in coconut gardens, a device for mechanical catching. *Indian Cocon. J.* 8(9): 6. (Coconut Res. Station, Kumarakom, Kerala).

## 10.4 Vertebrates

890. ADVANI, RANJAN. 1984. Ecology, biology and control of black rat *Rattus rattus* in Minicoy island. *J. Plantn Crops*. 12: 11-16 (CPCRI, Kasaragod, Kerala).

Ecological and biological studies on the predominant rodent pest of coconut in Minicoy island, the black rat, *Rattus rattus*, revealed a high level of infestation. Rats belonging to age class 111-140 g predominated the free living populations. Details on the biology are given in the paper.

Wooden traps and Sherman metal traps were found effective in capturing adult and sub-adult rats respectively, while wire cages were comparatively less successful. With the increase in palm density/ha, a rise in rodent infestation levels and relative damages were observed. Ten times more rodents were trapped on the crowns of coconuts than at ground level, suggesting to undertake poison and trapping operations on the crowns of coconut palms rather than at ground level.

891. ADVANI, RANJAN. 1984. Ecology, status and post-natal development of the black rat infesting coconut and cacao. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.626-632. (CPCRI, Kasaragod, Kerala).*

The common black rat, *Rattus rattus wroughtoni* Hinton (Rodentia : Muridae) is a predominant pest (72.5% relative abundance) of cacao and coconut crops, along with seven other species of rodents, three species of bats and one species of shrew. The weights and measurements of head and body were significantly ( $P=0.01$ ) more in males than in females. Of the total free living populations, females (54%) predominated. The highest prevalence

of pregnant females, subadult populations and high densities of *R. rattus wroughtoni* coincided with the low rainfall period from September to October. Low levels of reproduction and subadult population were encountered during high rainfall periods from June to August, since rainfall had an adverse effect on reproduction of rats.

892. ADVANI, RANJAN. 1985. Rodent pest management in the coconut plantations of India and its islands. *Indian Cocon. J.* 15(10): 3-10. (CPCRI, Kasaragod, Kerala).

This communication deals with the results pertaining to eco-toxicological studies on rodents infesting coconut crop of South India, Minicoy island (Lakshadweep) and Car Nicobar. Extent of rodent damage and rodent species infesting coconut crop at its different growth stages are discussed. Mechanical, chemical and biological methods of management have been suggested, keeping in view of the biological and behavioural patterns of rodents and cropping pattern.

893. BHAT, S. KESHAVA and SUJATHA, A. 1986. A study of the species of small mammals in mixed coconut - cacao gardens in Kerala. *Planter* 62(727): 428-432. (CPCRI, Kasaragod, Kerala).

When different groups of animals co-exist in a given habitat, correct identification and knowledge of its habits, habitat selection and association with other species is necessary for adoption of successful control operations. The species composition of small mammals in coconut-cacao mixed habitat was analysed in 5 gardens by setting wooden (30 x 12 x 11.5 cm) and Sherman (23 x 7.5 x 9 cm) 'live' traps on the branches as well as on the ground. *Rattus rattus wroughtoni* was the most predominant species followed by *Mus booduga*. *R. r. wroughtoni* was more common on the

A device for the control of rats in coconut fields was developed and described.

905. PATEL, A.J. and MITTAL, V.P. 1986. Evaluation of some rodenticides in coconut orchard. *Rodent Newsletter* 10(1 to 4): 8. (Dept. of Entomology, College of Agric., GAU, Junagadh, Gujarat).

Effectiveness of four rodenticides were tested in coconut fields.

906. RAO, A.M.K. MOHANA; SUBIAH, K.S.; MELKOTE, V.L. and RAO, A. RAMACHANDRA. 1983. Efficacy of crown baiting with warfarin and bromadiolone against rodents in coconut palms in Krishna district of Andhra Pradesh. *Indian Cocon. J.* 15(1): 6-9. (CPPTI, Rajajinagar, Hyderabad, A.P.).

Investigations on crown baiting of coconut palms using warfarin and bromadiolone baits embedded in paraffin were revealed that both are potent anticoagulants bringing a minimum mortality rate of 84% rodent population.

907. SUKUMARAN, A.S. and KURIAN, CHANDY. 1983. Rat damage to coconut; a review. *Indian Cocon. J.* 14(4): 3-7. (CPCRI (RS), Kayangulam, Kerala).

Damages to coconut in different ways have been reported to be caused by different species of rats. The nature and extent of damage and the control measures adopted are given in this review.

908. URS, Y.L. 1979. Damage to coconuts in a nursery plantation by *Bandicota bengalensis*. *PANS* 25(2): 147-149. (CFTRI, Mysore, Karnataka).

The Indian mole rat or bandicoot (*Bandicota bengalensis*) causes severe damage to coconut saplings raised in nurseries. It attacks saplings at a particular growth stage, consuming the cortex at the junction of the seed nut and shoot system. Maximum damage occurred at 13, 14 and 15 months after sowing. Effective rodent control programme in and around the nursery area needs to be implemented as soon as infestation occurs.

## 11. PHYSIOLOGY AND BIOCHEMISTRY

909. BABOO, BENGALI and RAMADASAN, A. 1986. Energy consumption and output of West Coast Tall coconut palm (*Cocos nucifera* L.) *J. Plantn Crops* 14(1):49-51. (CPCRI, Kasaragod, Kerala).

Under rainfed conditions a West Coast Tall Palm (its copra, husk, shell, dry leaves, spathe, peduncle and nut water) produces annually about 283,710 k cal of energy (the output). The input (labour, implements, NPK, green leaves and transport) is about 11,471 kcal/annum of energy consumption, giving an output input ratio of 24:73.

910. BAHADUR, BIR M.; RAO, MADHUSUDHANA, M.; CHANDRAIAH, K. and RAO, LOKENDAR. 1978. The physiological basis of handedness in relation to yield in *Cocos nucifera* L. *Incompatibility Newsletter* 9:108-111. (Dept. of Botany, Kakatiya Univ., Warangal, A.P.).

It is noted that, compared with left-handed palms, righthanded palms contain more chlorophyll/g of tissue and have larger stomata, a higher stomatal index, a lower transpiration rate and larger pollen grains.

911. BALACHANDRAN, C.; ARMUGHAN, C. and MATHEW, A.G. 1985. Distribution of major chemical constituents and fatty acids in different regions of coconut endosperm. *JAOCS* 62(11):1583-1586. (RRL, Trivandrum, Kerala).

Seven regions of coconut endosperm, comprising four (inner, middle, outer and testa) from the region adjacent to the water cavity to the testa, and three transverse regions from top to bottom, were analysed for moisture, fat, protein nitrogen, soluble sugars, reducing sugars, fibre, total ash and acid insoluble ash. A marked gradient in the concentration of major

constituents was observed across the endosperm from the inner region through middle and outer region and testa. Fatty acids, (6:0 to 12:0) were concentrated in the inner regions, and their contents decreased towards the outer regions with a corresponding increase in the higher acids and unsaturated fatty acids. The distribution of the constituents in the transverse regions of the coconut endosperm was fairly uniform.

912. BALACHANDRAN, C.; ARUMUGHAN, C.; PADMAKUMARI, K.P.; NARAYANAN, C.S. and MATHEW, A.G. 1987. Determination of soluble sugars in different regions of coconut endosperm by HPLC. *J. Plantn Crops* 15(2):125-130. (RRL, Trivandrum, Kerala).

The variation in soluble sugars in the different regions of the endosperm viz. inner, middle, outer, testa, anterior, central and posterior was determined. The inner region had the highest concentration of sugar followed by a steady gradient in the decreasing order in the other regions. Major sugars were glucose and sucrose while fructose, rhamnose, ribose, arabinose, maltose and raffinose were present in trace amounts.

913. CHAKRABORTHY, P. 1985. Functional properties of coconut protein isolate obtained by ultrafiltration. *J. Food Sci. Technol.* 2(4):248-254. (Dept. of Food Science & Technology, Jadavpur Univ., Calcutta, W.B.).

Ultrafiltration yielded 15% more coconut protein than acid coagulation. The protein content of the cream separated from coconut milk was 88% which was slightly lower than that obtained from acid precipitation. There was only 3.3% solid loss in the permeate during ultrafiltration. The protein obtained, by ultrafiltration had superior functional properties

and had higher chemical score due to better amino acid profile.

914. CHIKKASUBBANNA, V.; JAYAPRASAD, K.V.; SUBBAIAH THILAK and POONACHA, N.M. 1990. Effect of maturity on the chemical composition of tender coconut (*Cocos nucifera* L. var. *Arsikera Tall*) water. *Indian Cocon. J.* 20(12):10-13. (Div. of Horticulture, UAS, GKVK Campus, Bangalore, Karnataka).

A study on the effects of maturity on the physical and chemical parameters of tender coconut water was conducted to assess the optimum stage for harvesting the tender nuts. Data on nut weight, volume of water, weight of kernel, shell and fibre, TSS, pH, acidity, reducing and non-reducing sugars, N, protein, K and Na were recorded at monthly intervals. The results suggest that for obtaining adequate amounts of nutrients and sugars in the coconut liquid endosperm, the nuts should be harvested between the 7th and 8th month of maturity.

915. DWIVEDI, R.S.; MATHEW, CHACKO; MICHAEL, K.J.; RAY, P.K.; SUMATHYKUTTY AMMA, B. and NINAN, SUNNY. 1978. Carbonic anhydrase, carbon assimilation rate and canopy structure in relation to nut yield on coconut. *In: Symposium on Crops and Production Physiology, IARI, New Delhi, Feb. 27, 1978.* Proceedings of symposium. p. 54-56. (CPCRI (RS), Kayangulam, Kerala).

Carbonic Anhydrase (CA) activity decreased with the age of the leaves during dry season in all types of palms. However, CA was 5-10% more in erect canopied (EC) palms than spherical and semispherical canopies. Significant correlation is seen between CA activity, carbon assimilation rate and biologically active zinc. Based on this, the carbon assimilation rate of first fully opened and middle leaves may be taken as an index for predicting nut yield/dry matter production potentialities of seedlings.

916. DWIVEDI, R.S.; MATHEW, CHACKO; MICHAEL, K.J.; SUMATHYKUTTY AMMA, B.; RAY, P.K. and NINAN, SUNNY. 1978. Carbonic anhydrase, biologically active zinc and carbon fixation in coconut palm (abstract). *In: Symposium on Plantation Crops, 1st, RR11, Kottayam, 20-23 Mar. 1978.* Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p. 370. (CPCRI (RS), Kayangulam, Kerala).

Activity of carbonic anhydrase in the first fully opened leaf (FFL) of erect canopied palms (EC) was higher than that of spherical canopied palms (SC) but the reverse was true in case of middle leaves (ML). The carbon dioxide fixation rate of FFL and ML of SC palms did not differ significantly but in EC palms, CO<sub>2</sub> assimilation of former leaf was higher than latter one. The nut yield in SC palms was found to exceed by 1.2-2.5 times over that in EC palms, including diseased palms. Thus carbonic anhydrase activity and the biologically active zinc play an important role in regulating CO<sub>2</sub> fixation and nut yield of coconut.

917. GUPTA, D.N. SEN and SEN, S.P. 1982. Photochrome regulation of uptake of metabolites by coconut nuclei *in vitro*. *Plant. Sci. Lett.* 24:61-66. (Dept. of Botany, Univ. of Kalyani, W.B.).

Red (R) light inhibits and far red (FR) light promotes the uptake of (32p) orthophosphate, (14<sub>c</sub>) valine and (14<sub>c</sub>) sucrose by isolated coconut endosperm nuclei. The inhibition of the uptake of (14<sub>c</sub>) sucrose by a 5 min pulse of R light was reversible by a 5-min pulse of FR light which followed. Photochrome thus controls the uptake of metabolites by nuclei.

918. JAYAKUMAR, M.; SASEENDRAN, S.A. and HEMAPRABHA, M. 1988. Crop coefficient for coconut (*Cocos nucifera* L.) a lysimetric study. *Agric. Forest Meteorol.* 43(3-4):235-240. (CWRDM, Calicut, Kerala).

showed considerable differences between months and were influenced by the mean sunshine hours and not by the daily mean temperature. The active mobilisation of carbohydrates took place during the period when the rainfall also was high. The hybrids, however, were superior to WCT in mobilising the carbohydrates.

924. KASTURI BAI, K.V.; RAMADASAN, A. and SATHEESAN, K.V. 1980. Diurnal changes in specific leaf weight and starch content in coconut leaf (*Cocos nucifera* L.) *J. Ind. Bot. Soc.* 60:52-54. (CPCRI, Kasaragod, Kerala).

The diurnal changes occurring in specific leaf weight (SLW) and starch content is brought out. The changes between different timings were significant at 5% and 1% levels respectively. A linear relationship ( $r=-0.7961$ ) between SLW and starch content was observed.

925. KASTURI BAI, K.V.; VOLETI, S.R. and RAJAGOPAL, V. 1988. Water relations of coconut palms as influenced by environmental variables. *Agric. Forest Meteorol.* 43(3-4):193-199. (CPCRI, Kasaragod, Kerala).

A steady state porometer was used to measure meteorological parameters and stomatal resistance under field conditions. During the dry season, between 10.00 and 12.00 h there were increases in radiation, temperature and vapour pressure deficit (VPD), resulting in a higher stomatal resistance and a reduced leaf water potential. During the wet season, the reverse situation occurred. West Coast Tall palms had high leaf diffusive resistance, while the hybrid Chowghat Orange Dwarf x West Coast Tall was susceptible to stress conditions.

926. KRISHNAMOORTHY, B. and JACOB, P.M. 1984. Fruit component analysis in Lakshadweep coconuts. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p. 180-183. (CFTRI,

Mysore, Karnataka).

The N.K.N.V.I. method was used for the comparison of different types of coconut found in Lakshadweep islands. Fruit component analysis indicated that the different types of Lakshadweep coconuts belong typically to the Niu-Kafa class with higher proportions of husk and endosperm and Laccadive small is of immature, and arose perhaps due to introgressive hybridization between Laccadive Micro and Laccadive Ordinary types.

927. KRISHNAMURTHY, M.N. and CHANDRASEKHARA, N. 1978. Studies on changes in lipids of coconut processing. *Chem. Abstr.* 89(15):45. (CFTRI, Mysore, Karnataka).

The fatty acid composition of total, neutral and polar lipids of freeze-dried coconut, desiccated coconut and of coconut oil were determined. The fatty acid composition of the neutral lipid fraction was similar in all three, while the polar lipid fraction of coconut was rich in unsaturated fatty acids, (archidonic acid-35%, linoleic acid - 3.0%). On desiccation the unsaturated fatty acid decreased considerably, indicating oxidation even under mild conditions (drying at 60%). Neither of these fatty acids has been reported in coconut oil which explains the poor keeping quality of desiccated coconut and coconut-based foods vis-a-vis good keeping quality of coconut oil.

928. KRISHNAMURTHY, M.N. and CHANDRASEKHARA, N. 1979. Distribution of lipase in different parts of coconut (*Cocos nucifera* L.). *J. Food Sci. Tech.* 16(2):74-75. (CFTRI, Mysore, Karnataka).

A study of the distribution of lipase activity in different parts of the coconut showed that the cuticle had the highest specific activity whereas the endosperm and the layer immediately below the cuticle had about twentieth and sixth of the activity in the cuticle, respectively. Steaming for 15 min at 5 psi caused

nearly 70% inactivation, while desiccation at 60°C for 4 hr resulted in an additional loss of 25% activity. Thus desiccated coconut so prepared had only 6% of residual lipase activity.

929. KRISHNAMURTHY, M.N. and CHANDRASEKHARA, N. 1983. Polar lipids of coconut. *J. Food Sci. Tech.* 20(5):206-209. (CFTRI, Mysore, Karnataka).

Coconut lipids obtained by extraction with chloroform-methanol (2:1 v/v) contained phospholipids in contrast to the oil obtained by pressing or by extraction of coconut with a non-polar solvent. Fractionation of these lipids indicated 94.3 per cent neutral, 5.5 per cent glyco - and 0.2 per cent phospholipids. Monogalactosyl diglyceride was the predominant glycolipid and the major components of phospholipids were phosphatidyl choline, phosphatidyl ethanolamine and phosphatidyl inositol. Both glyco - and phospholipids were rich in unsaturated fatty acids and had iodine values of 41.6, 58.3 respectively. Linolenic acid was present in total (0.5 per cent) as well as in glycolipids (2.5 per cent).

930. KRISHNAMURTHY, K.V. and RAJACHIDAMBARAM, C. 1986. Factors associated with reduction in photosynthetic oxygen evolution in cement dust coated leaves. *Photosynthetica* 20(2):164-168. (Bharathidasan Univ. Tiruchirapalli, T.N.).

The rates of photosynthetic oxygen evolution by cement dust-coated leaves (*Borassus flabellifer*, Coconut, *Curcuma longa*, Tamarind) collected near the Chettinad Cement Factory were reduced by 72.8-83.6%, compared with the rates shown by leaves of the same specimen collected at a distance where no dust deposition occurred. The reduction in photosynthetic rate was due to the cumulative effects of the following: (1) a 50-80% reduction in incident irradiance at the leaf surface; (2) full or partial obstruction of

37-80% of the stomata, preventing gas exchange; (3) shrinkage of the guard cells and subsidiary cells induced by the alkaline solution formed by the dust and transpirational water resulting in stomatal collapse (3-25%), (4) a 56-68% reduction in leaf chlorophyll (a+b) content probably due to reduced chlorophyll synthesis.

931. LUBINA, R. 1990. Effect of irrigation and nutrient levels on water relation of coconut genotypes. M. Phil. dissertation. Mangalore University, Mangalore. 100 p. (CPCRI, Kasaragod, Kerala).

The effect of summer irrigation and nutrient levels on the water relations of WCT and COD x WCT palms was studied under field conditions. Effect of moisture stress on the proline content and nitrate reductase activity as well as the leaf nutrient levels were also studied. Stress induced increase in proline content and decrease in nitrate reductase activity were also observed. A possible relationship between potassium supply, stress parameters and enzyme activity has been established.

932. MANJULA, C. 1990. Physiological and biochemical changes during the germination of coconut seeds. M. Phil. dissertation. Mangalore University, Mangalore. 85p. (CPCRI, Kasaragod, Kerala).

The rate of uptake of water was more in late germinating ones as compared to early germinating ones. The development of haustorium, shoot and root started earlier in dwarfs than the tall and hybrid, but at later stages the growth of root and shoot was more in the latter case. Solubilisation of reserve food materials mainly lipids, was faster as also the activity of hydrolytic enzymes in the early germinating ones than in the other two. The haustorium, shoot and root draw the nutrients for their growth from kernel and nut water as shown by the higher concentration of total

Consumptive water use was measured in volumetric lysimeters. Mean consumptive use of water by 6-year-old palms with a leaf area index of 2.4 during the observation period (Nov. 1986 to May 1987) was of the order of 3.3 mm/day and ranged from 2.7 to 4.1 mm/day. The crop coefficient values were 0.54, 0.73, 0.60 and 0.65 for the Penman, Blaney-ridgill, radiation and US Class-A pan methods, respectively.

919. JAYALEKSHMY, A.; ARUMUGHAN, C. and NARAYANAN, C.S. 1986. Changes in the chemical composition of coconut water during maturation. *J. Food Sci. and Technol.* 23(4): 203-207. (RRL, Trivandrum, Kerala).

Coconut bunches were harvested from a healthy tree (West Coast Tall variety) and numbered I to VIII in order of increasing maturity and chemical composition analysed. Nut water volume, total solids, sugars, ash and mineral constituents were markedly reduced during maturation. However, the fat and protein contents of coconut water increased with maturation.

920. KAMALA DEVI, C.B. and VELAYUDHAM, M. 1978. Changes in the chemical composition of nut water and kernel during development of coconut. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I.* Edited by E.V. Nelliath and others. p. 340-346. (CPCRI, Kasaragod, Kerala).

Maximum quantity of nut water was observed in six month old nuts. The sugar content of the nut water and kernel were maximum in eight month old nuts irrespective of the genotype. Potassium was the predominant in nut water. Oil content increased with a corresponding decrease in nut water acidity and sugar content in water and kernel.

921. KASTURI BAI, K.V. and RAMADASAN, A.

1978. Changes in leaf carbohydrates in relation to commencement of flowering in coconut palm. *In: symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I.* Edited by E.V. Nelliath and others. p.321-330. (CPCRI, Kasaragod, Kerala).

Changes in leaf carbohydrates were monitored in a group of young palms for a duration of three years during which period six of them commenced flowering. The changes in carbohydrate fractions, as influenced by the environmental factors, in the palms that commenced flowering during the period under study are discussed.

922. KASTURI BAI, K.V. and RAMADASAN, A. 1982. Changes in the carbohydrate fractions in relation to female flower production in coconut. *J. Plantn Crops* 10(2):124-126 (CPCRI, Kasaragod, Kerala).

Monthly fluctuations in stem and leaf starch, stem and leaf sugar and flower number were determined over 2 years. The data are presented graphically. The similar trend was noticed for both years. The maximum production of female flowers in March and April was accompanied by the highest starch content in the stems and leaves and by the lowest level of soluble carbohydrates.

923. KASTURI BAI, K.V. and RAMADASAN, A. 1983. Changes in the levels of carbohydrates as a function of environmental variabilities in hybrids and Tall coconut palms. *In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976,* edited by N.M. Nayar. New Delhi: Wiley Eastern. p. 203-209. (CPCRI, Kasaragod, Kerala).

Leaf carbohydrate fractions in three-year old seedlings of the cultivars West Coast Tall x Gangabondam, West Coast Tall X Chowghat Dwarf Orange, Chowghat Dwarf Orange X West Coast Tall and West Coast Tall palms

sugars, reducing sugars and amino acids in these tissues.

933. MARTIN, JAMES, G. and RAMACHANDRAN, T.K. 1989. Scientific management of coconut palms under water stress. *Far. Paliament* 18(3):13-14 (Coconut Res. Station, TNAU, Veppankulam, T.N.).

The scanty and uneven distribution of rainfall experienced in the southern states of India viz. Kerala, Karnataka and Tamil Nadu, imposes certain level of stress to the coconut palms, which can be alleviated by conversion of moisture and effective utilization of water. Moisture conservation can be achieved by adopting methods like husk burial, husk mulch, coir mulch, FYM/compost application, cover cropping and intercultivation while pitcher irrigation and drip irrigation facilities reduce the severity of stress. Physiological approaches like defoliation to reduce transpirational loss and planofix spray to increase the fruitset can also be adopted to mitigate the problems due to water stress.

934. MATHEW, A.S. and RAMADASAN, A. 1976. Photosynthetic efficiency in relation to annual yield and chlorophyll content in the coconut palm. *J. Plantn Crops* 3(1):26-28. (CPCRI (RS), Kayangulam, Kerala).

Rate of apparent photosynthesis in the West Coast Tall coconut palms was significantly correlated with annual yield of nuts and chlorophyll content in leaves. The chlorophyll content was also significantly correlated with annual yield of nuts.

935. MATHEW, G.; VASU, K.; VAMADEVAN, V.K. and WAHID, P.A. 1988. Measurement of transpiration rate in coconut palm with tritiated water; tritium profile in coconut crown. *J. Nuclear Agric. Biol.* 17(2):110-112. (CWRDM, Calicut, Kerala).

The methods of injecting tritium into the

trunk and sampling of the leaves are outlined. The flow of tritium to different parts of the crown was not uniform, which took less time to reach younger leaves than mature leaves, suggesting a lower transpiration rate in the latter.

936. MITRA, R. and SEN, S.P. 1976. Effect of some plant sterols, steroids and triterpenoid on the RNA synthesis in plants. *Plant Biochem. J.* 2(2):82-97.

The effect of several steroids, phytosterols and triterpenoids on RNA synthesis in pea (*Pisum sativum*) broad bean internode sections and isolated coconut endosperm nuclei as evinced by  $32_p$  orthophosphate and  $14_c$  uracil incorporation was studied. Oestradiol-17B alone stimulated RNA synthesis while progesterone, showed 50% inhibition, including nuclear RNA.

937. NAIR, R.B. and SADANANDAN, A.K. 1976. Variation in glucose content of coconut in Andaman palms. *In: International Symposium on Coconut Research and Development, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976. Abstracts of papers.* p.18. (CPCRI (RC), A. & N. Islands.).

Tall palms showed significant variation in the glucose content in 6-month old fruits (2.40-6.25%, Mean-4.04%), while in dwarfs there was less variation. (3.00-3.60%, Mean-3.34%). Glucose content did not vary with reference to colour, but showed an inverse relation with the size of the fruits.

938. PADMAJA, G.; SUMATHYKUTTY AMMA, B.; MATHEW, CHACKO; NAMBIAR, P.T.N. and DWIVEDI, R.S. 1980. Carbonic anhydrase activity versus acidity in low yielding and high yielding coconut palms (*Cocos nucifera* L.) *Indian J. Expt. Biol.* 18:1209-1211. (CTCRI, Trivandrum, Kerala).

Activity of Carbonic Anhydrase (CA) as well as the titratable acidity were determined in unfertilized female flowers, one month old

and two months old buttons from West Coast Tall Variety of coconut. An increased CA activity was noticed in the high yielding coconut palms. A reciprocal relationship was obtained between CA activity and titratable acidity, suggesting CA as a key enzyme in regulating the pH of the plant cell.

939. POTTY, V.P.; JOSEPH, K.V.; JAYASANKAR, N.P. and HARIHARASUBRAMANIAN, V. 1976. Elimination of tannins from coconut leaves. *J. Plantn Crops*. 3(2):86-87. (CPCRI (RS), Kayangulam, Kerala).

90% of the tannins could be removed from coconut leaves by mixing the leaves in a waring blender containing 1% gelatin and 1% mercaptoethanol.

940. RAJAGOPAL, V.; KASTURI BAI, K.V.; PILLAI, R.V. and VIJAYAKUMAR, K. 1990. Relationship between physiological characters and nut yield in coconut genotypes under rainfed condition. In: Symposium on Plantation Crops, 9th, CCRI, Chickmagalur, Dec. 5-7, 1990. Abstracts of papers. p. 67. (CPCRI, Kasaragod, Kerala).

Physiological characters like the leaf diffusive resistance (SR), transpiration rate (TR), leaf water potential (WP) and epicuticular wax content (ECW) were used to screen for drought tolerance in the coconut genotypes comprising of 10 tall, 6 dwarfs and 7 hybrids. There was significant correlation between these physiological characters and yield performance. Some of the genotypes which were identified as drought tolerant also proved to be good yielders, thus highlighting the significance of using these characters in screening for drought tolerance and to aid breeding strategy in coconut.

941. RAJAGOPAL, V.; KASTURI BAI, K.V.; RAMADASAN, A.; BALASIMHA, D.; VOLETI, S.R.; PATIL, K.D.; SUMATHYKUTTY AMMA, B.; VARKEY, T.; MATHEW, A.S. and GOPALAKRISHNAN NAIR, M. 1986. Leaf

characteristics and dry matter production in coconut (WCT and COD x WCT) grown under conditions of low and high drought intensities. In: Workshop on Impact of Drought on Plantation Crops, CPCRI, Kasaragod, May 26-27, 1986. Extended summaries. p. 33-34. (CPCRI, Kasaragod, Kerala).

Studies were undertaken to evaluate the response of WCT and CODxWCT grown at Kayangulam (low intensity drought) and at Kasaragod (high intensity drought). The results indicated differential response of palms to available soil moisture regimes which was reflected in the water relation components and nut yield. The genotypes at Kasaragod exhibited higher stomatal resistance, low transpiration rate coupled with higher epicuticular wax content than the genotypes at Kayangulam indicating the intensity of drought at Kasaragod. Both genotypes found better at Kayangulam than at Kasaragod.

942. RAJAGOPAL, V.; KASUTRI BAI, K.V. and VOLETI, S.R. 1990. Screening of coconut genotypes for drought tolerance. *Oleagineux* 45(5):215-223. (CPCRI, Kasaragod, Kerala).

23 coconut genotypes studied in Kerala, India, had shown varying responses to the prevailing soil and atmospheric conditions during the summer months. Tall genotypes had a relatively high stomatal resistance (RS), leaf water potential and epicuticular wax content as compared to the dwarfs. Lower transpiration rate resulting in effective conservation of water in tissues was observed between November and March in some tall palms and hybrids. Parametric relationships with drought tolerance based on the rank sum led to the identification of few genotypes with the desirable drought tolerance characters.

943. RAJAGOPAL, V.; KASTURI BAI, K.V.; VOLETI, S.R. and SHIVASHANKAR, S. 1988. Water stress in coconut palms. Paper presented in the

International Congress of Plant Physiology, New Delhi, Jan. 15–20, 1988. (CPCRI, Kasaragod, Kerala).

The genotypes CODxWCT, WCT and WCTxCOD responded to moisture stress to different degrees. WCT and WCTxCOD were characterised by higher stomatal resistance and higher leaf water potential. Epicuticular wax content as well as APH and GOT activities increased under stress. The total nut yield and kernel dry weight decreased in CODxWCT than in other two genotypes under both rainfed and irrigated conditions.

944. RAJAGOPAL, V.; MATHEW, CHACKO and VARKEY, THOMAS. 1982. Determination of stomatal resistance and transpiration rate in the leaves of coconut (*Cocos nucifera* L.) using the steady state porometer. In: International Workshop on Special Problems in Physiological Investigations of Tree Crops, RR11, Kottayam, Aug. 26-28, 1982. Proceedings of workshop. Edited by M.R. Sethuraj and others. p. 100–104. (CPCRI (RS), Kayangulam, Kerala).

The stomatal resistance and transpiration rate were determined in the leaves of young and adult coconut palms using a steady state porometer. A comparative study made between the 'intact' and 'excised' leaflets indicated that there was no significant difference between 'intact' and 'excised' leaves in their diffusive resistance. Determination of the stomatal resistance within two minutes after the excision of leaflets gave accurate values.

945. RAJAGOPAL, V.; RAMADASAN, A.; KASTURIBAI, K.V. and BALASIMHA, D. 1989. Influence of irrigation on leaf water relation and dry matter production in coconut palms. *Irrig. Sci.* 10:78–81. (CPCRI, Kasaragod, Kerala).

The effect of different frequencies of irrigation on the leaf water relations and dry matter production of WCT palms was studied. Irrigation treatments resulted in a four to five

fold increase in the soil water deficit at I/E ratios of 0.5 and 0.0 as compared to 1.0. Coconut palms experienced severe moisture stress at an irrigation level of 0.5 which is reflected on the leaf water relations and dry matter production.

946. RAJAGOPAL, V.; SHIVASHANKAR, S.; KASTURIBAI, K.V. and VOLETI, S.R. 1988. Leaf water potential as an index of drought tolerance in coconut. *Cocos nucifera* L. *Pl. Physiol. Biochem.* 15:80–86. (CPCRI, Kasaragod, Kerala).

Adult coconut palms comprising the tall WCT and Laccadive ordinary (LO), the dwarfs Chowghat Orange Dwarf (COD) and Gangabondam (GB) and the hybrids (WCTxCOD, CODxWCT, LOxGB and LOxCOD) were screened for drought tolerance using leaf water potential ( $\psi$ ) measurement. When subjected to dehydration the  $\psi$  declined with time to different degrees among genotypes except for LOxCOD, WCT and LOxGB which had higher  $\psi$  irrespective of the time of dehydration. These three genotypes had lower activities of Acid Phosphatase (APH) and Glutamate Oxaloacetate Transaminase (GOT). Thus  $\psi$  measurement serves as an index of drought tolerance in coconut.

947. RAJAGOPAL, V.; VOLETI, S.R.; KASTURIBAI, K.V. and SHIVASHANKAR, S. 1988. Physiological and biochemical criteria for breeding for drought tolerance in coconut. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Nov. 23–26, 1988. Abstracts of papers. p. 18. (CPCRI, Kasaragod, Kerala).

Coconut genotypes were screened to assess the degree of tolerance to stress based on the soil moisture depletion by roots, transpiration rate, leaf surface wax (ECW) and enzyme activities. Thus, the hybrids WCTxWCT, LOxGB, LOxCOD, WCTxCOD, and the tall WCT and Andaman Giant proved to be drought

tolerant in having lower soil moisture depletion, lower transpiration rate and higher ECW as compared to the dwarfs like COD, MYD, GB, MOD, Laccadive Micro and the hybrid CODxWCT, which were found to be drought susceptible. The activities of Glutamate Oxaloacetate Transaminase (GOT) and Nitrate Reductase (NR) also showed distinct differences between tolerant and susceptible genotypes.

948. RAMADASAN, A. 1985. A comparative study of certain morphological and physiological characters associated with productivity of coconut (*Cocos nucifera* L.) and oil palm (*Elaeis guineensis* Jacq.). *Indian Cocon. J.* 15(12):7-11. (CPCRI, Kasaragod, Kerala).

Certain plant characters in coconut like first flowering, leaf axil, annual rate of leaf production, mean number, of bunches/year, duration for nut maturity, age for yield stabilization, density of planting which are related to productivity have been compared with those of oil palm. Leaf characters, leaf area index and dry matter production figures are also presented in comparison with oil palm.

949. RAMADASAN, A.; KASTURIBAI, K.V.; SHIVASHANKAR, S. and VIJAYKUMAR, K. 1985. Heritability of seedling vigour in coconut seedling. *J. Plantn Crops* 13(2):136-138. (CPCRI, Kasaragod, Kerala).

Heritability in NAR, total chlorophyll content and shoot dry weight had been estimated. The results indicated high heritability for total shoot dry weight, the NAR and total chlorophyll content which suggest that in WCT palms the efficiency of dry matter production is a heritable factor.

950. RAMADASAN, A. and MATHEW, CHACKO. 1977. Relationship of the carbohydrate reserve in the trunk with commencement of flowering in young West Coast Tall coconut palms. *J. Plantn Crops* 5(2):125-126. (CPCRI, Kasaragod, Kerala).

Significant increases in the carbohydrate reserve and carbohydrate/nitrogen ratio influenced the flowering pattern of the coconut palms.

951. RAMADASAN, A.; MATHEW, CHACKO; MATHEW, JACOB and SATHEESAN, K.V. 1984. Relative assimilation rate (RAR) in coconut palms. *J. Plantn Crops* 12(12): 186-188. (CPCRI, Kasaragod, Kerala).

The Relative Assimilation Rate (RAR) in 3 year-old palms was highest in the youngest opened leaf which was selected for further studies with 15 to 20 year old West Coast Tall (WCT) and Chowghat Dwarf Green (CDG) palms. The mean RAR values for 23 WCT palms ranged from 1.9 to 5.9 gm<sup>-2</sup> week<sup>-1</sup> and for 20 CDG palms from 1.2 to 3.9 gm<sup>-2</sup> week<sup>-1</sup>. A positive correlation between RAR and mean annual yield was observed.

952. RAMADASAN, A.; MATHEW, CHACKO and SATHEESAN, K.V. 1982. Rate of Photosynthesis and dry matter production in coconut palms. *In: International Workshop on Special Problems in Physiological Investigations of Tree Crops, RRII, Kottayam, Aug. 26-28, 1982.* (CPCRI, Kasaragod, Kerala).

Physiological basis for variation in the yield of coconut palms was studied. Gaseous exchange and growth analysis methods were employed. The results obtained are discussed.

953. RAMADASAN, A. and MATHEW, JACOB. 1987. Leaf area and dry matter production in adult coconut palms. *J. Plantn Crops* 15 (1):59-63. (CPCRI, Kasaragod, Kerala).

Regression equations were developed for the nondestructive estimation of leaf area and dry matter production in adult palms. Suitability of these equations for the estimation of annual dry matter production by least destruction has been discussed.

954. RAMADASAN, A. and RAJAGOPAL, V.

1987. Coconut. In: Tree crops physiology. Edited by M.R. Sethuraj and A.S. Raghavendra. p. 169–192. Amsterdam: Elsevier Publishers. (CPCRI, Kasaragod, Kerala).

An extensive review on the physiological investigations carried out so far on coconut including growth, development, carbon and nitrogen metabolism, flowering, biomass production and harvest yield and index, changes during root (wilt) disease is given. The results discussed attempt to probe into the production characters responsible for limiting productivity.

955. RAMADASAN, A.; SATHEESAN, K.V. and BALAKRISHNAN, R. 1980. Leaf area and shoot dry weight in coconut (*Cocos nucifera* L.) seedling selection. *Indian J. agric. Sci.* 50(7): 553–554. (CPCRI, Kasaragod, Kerala).

Path-coefficient analysis was used to assess the contribution of various seedling characters that are presently employed for selection of coconut seedlings from 1 year old nursery. The girth at collar and the leaf area contributed mostly to the shoot dry weight. The number of leaves and the height of seedlings did not significantly contribute to vigour. A simple multiple linear regression equation was worked out for estimating the shoot dry weight non-destructively.

956. RAVEENDRAN, T.S.; VIJAYARAGHAVAN, H. and RAMACHANDRAN, T.K. 1989. Physiological aspects and production trends of certain coconut hybrids and their parents. *Cocos* 7:36–41. (RARS, TNAU, Veppankulam, T.N.).

Physiological basis for the variation in production trends of certain coconut hybrids and their parents was studied. Chlorophyll content, Photosynthetic rate, soluble protein and Nitrate Reductase activity and low respiratory rates were found useful in selecting vigorous seedlings in the nursery stage itself.

957. SARANGAMATH, P.A.; SHANTAPPA, P.B.

and KULKARNI, D.S. 1983. Varietal differences in nut and copra characters. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, 27–31, 1976, edited by N.M. Nayar. p. 181–185. (UAS Subcentre, Arsikere, Karnataka).

Nuts were sampled from the coconut cultivars of Spicata, Gangabondam, Fiji, Kaithathali, Laccadive Dwarf, Andaman Dwarf, West Coast Tall, Philippines Ordinary, S.S. Green and Kappadam and analysed for moisture, protein, phosphorous, potassium, calcium, magnesium, crude fibre, and total mineral contents. Correlation coefficients were worked out for various constituents. A high correlation was found between yield of copra and ash content ( $r=0.6982$ ).

958. SATHEESAN, K.V. 1984. Physiology of growth and productivity of turmeric (*Curcuma domestica* Val.) in monoculture and as an intercrop in coconut garden. Ph.D. thesis. University of Calicut, Calicut. 259 p. (CPCRI, Kasaragod, Kerala).

A study on the growth and development of three turmeric cultivars viz. Cls. No. 24(C<sub>1</sub>); C 11–328, Sugandham (C<sub>2</sub>) and Duggirala (C<sub>3</sub>) in monoculture and as an intercrop in coconut garden was conducted and results discussed. The differential response of turmeric towards LAI, NAR, relationship between cumulative LAD and dry matter production were worked out. In addition, PAR interception efficiency, the productivity in relation to light saturated rates of photosynthesis, the linear relationship between rhizome yield and biological yield are brought out. The three cultivars showed marked differences in their curcumin and essential oil contents and their response towards the cropping system.

959. SATHEESAN, K.V.; NARASIMHAYYA, G. and RAMADASAN, A. 1983. A rapid method for estimation of leaf area of one year old

seedlings of Tall variety of coconut palms. *J. Plantn Crops* 11(1):47-49. (CPCRI, Kasaragod, Kerala).

The area of an individual leaf (P) in any position in 1 year-old coconut seedlings (cv. West Coast Tall), can be estimated from the formula:  $p=27.39+0.6X$  in  $\text{cm}^2$ , where X=lamina length x width, with an accuracy of 91%. The total functional leaf area (Y) can be estimated from the formula  $\log Y=-0.434+1.042 \log (N)+1.0601 (X_m)$ , where N is the number of leaves, and  $X_m$  is the mean product of length and width of all leaves, with 99% accuracy.

960. SATHEESAN, K.V. and RAMADASAN, A. 1987. Curcumin and essential oil contents of three turmeric (*Curcuma domestica* Val.) cultivars grown in monoculture and as intercrop in coconut garden. *J. Plantn Crops* 15(1):31-37. (CWRDM, Calicut, Kerala).

The concentration and accumulation of curcumin and essential oil in the rhizomes of three turmeric cultivars grown in monoculture and as an intercropping in coconut garden were determined. Differential response towards the cropping systems was seen. The maximum concentration of curcumin and essential oil was attained prior to the maturity of the rhizome.

961. SATHEESAN, K.V. and RAMADASAN, A. 1988. Changes in carbohydrate levels and starch/sugar ratio in three turmeric (*Curcuma domestica* Val.) cultivar grown in monoculture and as an intercrop in coconut garden. *J. Plantn Crops* 16(1):45-51. (CPCRI, Kasaragod, Kerala).

Changes in the carbohydrate fractions have been studied in the *C. longa* cultivars Cls. No. 24, Cll. 328 Sugandham and Duggirala grown in monoculture and as an intercrop in coconut. Cls. No. 24 showed higher accumulation of starch in leaves and rhizomes. Duggirala showed no difference when grown in monoculture than as an intercrop. The reduction in starch-sugar ratio in leaves was

more pronounced in Cls. No. 24, indicating more efficient translocation of photosynthates.

962. SATHEESAN, K.V.; and RAMADASAN, A. 1988. Effect of growth retardant CCC on growth and productivity of turmeric under monoculture and in association with coconut. *J. Plantn Crops* 16 (2):141-143. (CPCRI, Kasaragod, Kerala).

An attempt to modify the assimilate partitioning of turmeric by the application of growth retardant CCC in different cropping system is made. Under intercropping the tiller production of turmeric was significantly higher for CCC treatments with 2000 ppm and 4000 ppm as compared to monoculture.

963. SATHEESAN, K.V. and RAMADASAN A. 1990. Physiological characteristics of leaves as indicators of shade tolerance in turmeric cultivars when grown as an intercrop in coconut gardens. *In: Symposium on Plantation Crops, 9th, CCRI, Chickmagalur, Dec. 5-7, 1990. Abstracts of papers. p.67.* (CWRDM, Calicut Kerala).

The effect of natural shade on different physiological characteristics of leaves such as apparent photosynthesis, chlorophyll content, air space volume, specific leaf area (SLA) etc. was studied in three cultivars of turmeric viz., Cls. No. 24 (C<sub>1</sub>), Cll. 328 Sugandham (C<sub>2</sub>) and Duggirala (C<sub>3</sub>) grown in monoculture and as an intercrop in coconut garden. Higher photosynthetic rate, higher SLA, higher chlorophyll b and lower chlorophyll a/b ratio were observed for all the cultivars under intercropping system, while C<sub>1</sub> alone showed higher photosynthetic rate under monoculture.

964. SHIVASHANKAR, S. 1986. Enzymes as indicators of water stress in coconut. *In: Workshop on Special Problems in Physiological Investigations of Tree Crops, CPCRI, Kasaragod, May 26-27, 1986. Summaries of papers. p. 65-66.* (CPCRI, Kasaragod, Kerala).

Monitoring of the enzyme activities during drought stress showed that changes in the activities of Acid phosphatase and L-Aspartate: 2-Oxoglutarate aminotransferase could serve as sensitive indicators of stress.

965. SHIVASHANKAR, S. 1988. Polyphenol oxidase isozymes in coconut genotypes under water stress. *Pl. Physiol. Biochem.* 15(1):87-91. (CPCRI, Kasaragod, Kerala).

Coconut genotypes growing under rainfed and irrigated conditions were analysed for leaf polyphenol oxidase (PPO) activity during the development of water stress. The rainfed palms showed increased PPO activity with increasing levels of stress, while the activity in irrigated palms, remained constant, the extent of increase being more in Chowghat Orange Dwarf x West Coast Tall (COD x WCT) and WCT x COD hybrids than WCT. Comparison of PPO isozymes on electrophoresis showed two additional fast moving bands in WCT x COD and COD x WCT hybrids under induced stress by air desiccation and by treatment with PEG-6000. There was no change in WCT and COD between the control and stressed leaves indicating the differential degree of tolerance to stress among the genotypes.

966. SHIVASHANKAR, S. 1990. Studies on soluble enzyme systems of coconut (*Cocos nucifera* L.) cultivars. Ph.D. thesis. Mysore University, Mysore. 200 p. (CPCRI, Kasaragod, Kerala).

Biochemical changes occurring in the drought tolerant and susceptible coconut genotypes under natural stress and polyethylene glycol-induced osmotic stress have been studied. Changes in the isozyme pattern of peroxidase, polyphenol oxidase and acid phosphatase of these genotypes were found related to their drought tolerance. Acid phosphatase isozymes were partially purified from normal and stressed tissues and their kinetic

properties have been compared. The results show that the acid phosphatase isozyme II undergoes conformational changes during stress development.

967. SHIVASHANKAR, S. 1990. Thermal stability of nitrate reductase in relation to drought tolerance in coconut. *In: Symposium on Plantation Crops, 9th, CCRI, Chikmagalur, Dec. 5-7, 1990. Abstracts of papers. p. 65-66.* (CPCRI, Kasaragod, Kerala).

The leaf Relative Water Content (RWC) and Nitrate Reductase (NR) activity of a few coconut genotypes showed considerable reduction under natural stress. NR activity showed a positive correlation with RWC, but was very low when the temperature effect (T max) was eliminated. On the contrary, T max showed a strongly negative correlation with NR activity. As such, the effect of pretreating the leaves at various temperatures on the NR activity indicated differences in the thermal stability of NR *in vivo*. This could be employed as an additional parameter in screening for drought tolerance.

968. SHIVASHANKAR, S.; BIDDAPPA, C.C. and KASTURI BAI, K.V. 1989. Effects of heavy metals on the respiration rate, chlorophyll content and nitrate reductase activity of coconut (*Cocos nucifera* L.) seedlings. *In: Strat. Physiol. Regul. Plant Productivity: proceedings of the national seminar, ISPP, Bombay, Dec. 27-29, 1989. p. 235-242.* (CPCRI, Kasaragod, Kerala).

Accumulation of heavy metals in the roots of WCT seedlings grown in sand culture is seen, reducing the leaf chlorophyll content and nitrate reductase activity. Rate of dark respiration was also found affected.

969. SHIVASHANKAR, S. and KASTURI BAI, K.V. 1988. A comparative study of the growth and nitrogen accumulation capacity of hybrid coconut seedlings. *Philipp. J. Cocon. Studies* 13(1):24-29. (CPCRI, Kasaragod, Kerala).

MYDxWCT seedlings exhibited higher net assimilation rate (NAR), relative growth rate (RGR), crop growth rate (CGR), leaf area index (LAI) and leaf area ratio (LAR) in comparison with MODxWCT and CODxWCT. Nitrate reduction through NR activity by leaves and the Nitrogen uptake Efficiency (NupE) were higher in MYDxWCT than MODxWCT and CODxWCT. The data shows the superiority of MYDxWCT over the other two hybrids.

970. SHIVASHANKAR, S. and KASTURI BAI, K.V. 1989. Ammonium enhances the nitrate induced nitrate reductase activity in coconut (*Cocos nucifera* L.) leaves. *J. Plantn Crops* 16(Suppl.): 55–60. (CPCRI, Kasaragod, Kerala).

Induction of nitrate reductase (NR) activity by nitrate in excised leaves of low and high yielding palms was markedly different, requiring lower levels of nitrate for optimum induction in the latter. Ammonium enhanced the induction under both light and dark conditions as also the Nitrate uptake in the induction medium.

971. SHIVASHANKAR, S.; KASTURI BAI, K.V. and RAMADASAN, A. 1982. Comparative study of coconut genotypes for components of photosynthesis and respiration. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 12–15, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p. 231–234. (CPCRI, Kasaragod, Kerala).

Physiological parameters were compared in three coconut genotypes WCT, COD and hybrid WCTxCOD. The results are presented and discussed.

972. SHIVASHANKAR, S.; KASTURI BAI, K.V. and VIJAYAKUMAR, K. 1986. A non destructive method for the estimation of leaf area and shoot dry mass in seedlings of coconut (*Cocos nucifera* L.) hybrids. *Philipp. J. Cocon. Studies* 11(2):9–12. (CPCRI, Kasaragod, Kerala).

Linear regression equations were devel-

oped to estimate the leaf area and shoot drymass in five coconut hybrids.

973. SHIVASHANKAR, S. and RAMADASAN, A. 1983. Nitrate reductase activity in coconut leaves. *J. Sci. Food Agric.* 34:1179–1184. (CPCRI, Kasaragod, Kerala).

The effect of various assay parameters on *in vivo* nitrate reductase activity in coconut leaf tissue was studied. n-Propanol inhibited the activity and light stimulated the same, which was not restored by the addition of glucose to dark treated leaves. 14th leaf on the coconut crown is the most appropriate for sampling. The inducible NR activity showed a high positive correlation with annual yield.

974. SHIVASHANKAR, S. and RAJAGOPAL, V. 1983. Diurnal rhythm in nitrate reductase activity of *Cocos nucifera* L. leaves. *Z. Pflanzenphysiol.* 112(2):181–185. (CPCRI, Kasaragod, Kerala).

Nitrate reductase activity in the leaves of *Cocos nucifera* exhibited a strong diurnal rhythm with a peak at 2 p.m. which was maintained under different dark or light conditions. The NR activity was independent of tissue nitrate level.

975. SHIVASHANKAR, S.; RAJAGOPAL, V. and RAMADASAN, A. 1985. Chlorophyll and nitrate reductase activity in relation to heterosis in coconut seedlings. *Ann. Bot.* 55:755–758. (CPCRI, Kasaragod, Kerala).

The F<sub>1</sub> progeny of Chowghat Orange Dwarf (COD) and West Coast Tall (WCT) cross tend to be highly heterozygous with respect to the colour of petiole and seedling vigour. Greenish coloured vigorous plants had higher chlorophyll (a+b) content and nitrate reductase (NR) activity as compared to the orange coloured vigorous plants and the dwarfs. The greenish brown seedlings were characterised by a larger leaf area and shoot dry weight. The results

provide biochemical evidence in support of morphological criteria being used in seedlings selection.

976. SINGH, R.P. and KARTHA, A.R.S. 1978. Note on the fatty acyl group distribution patterns in fats from ripening nuts of arecanut and coconut at different stages of maturity and their significance in triglyceride formation mechanism in plant. *Indian. J. agric. Sci.* 45(8):389-391. (IARI, New Delhi).

The triglyceride structure of areca nut (*Areca catechu* L.) and coconut (*Cocos nucifera* L.) fats at different stages of ripening was reported. During ripening of seeds producing lower saturated fatty acids, changes in the saturated: unsaturated ratio of fats can take place without involving any changes in the relative proportions of the different saturated fatty acids present.

977. SUMATHYKUTTY AMMA, B. and PILLAI, N.G. 1978. A preliminary study on the organic acids in the coconut palm tissues. *Indian Cocon. J.* 8(9):4-5. (CPCRI (RS), Kayangulam, Kerala).

Malic, oxalic, citric, malonic and succinic acids were identified in the different tissues of coconut palm and the possible presence of sulphamic, ascorbic and fumaric acids is indicated.

978. VENUGOPALAKRISHNA KURUP, V. 1989. Changes in epicuticular wax, lipids and membrane stability of coconut genotypes during stress development. M. Phil. dissertation. Mangalore University, Mangalore. 75p. (CPCRI, Kasaragod, Kerala).

It was concluded from the investigations that tall genotype West Coast Tall and the hybrid with Tall as female parent ie. West Coast Tall x Chowghat Orange Dwarf are relatively more tolerant to moisture stress than the hybrid with the dwarf as the female parent ie. Chowghat

Orange Dwarf x West Coast Tall.

979. VIJAYAN, K.P.; LOUIS, I. HENRY; CHANDRASEKHAR, N.R. and JAYARAMAN, C. 1977. Potassium content in nut water of 31 coconut varieties and hybrids. *J. Plantn Crops.* 5(2):123-124. (RARS, TNAU, Veppankulam, T.N.).

In tender and ripe nuts the K content of the water ranged from 0.232 to 0.360 g/100 ml and from 0.200 to 0.280 g/100 ml, respectively. In tender nuts Fiji had the highest K content, followed by San Blas and Adirampattinam Dwarf. In ripe nuts the highest K content was found in Fiji and Ayiramkachi.

980. VIJAYARAGHAVAN, H.; RAVEENDRAN, T.S. and RAMANATHAN, T. 1989. Effect of certain growth regulators in preventing button shedding and increasing yield in coconut. *Indian Cocon. J.* 20(2):3-7, 1989. (RARS, TNAU, Veppankulam, T.N.).

Studies on the effect of growth regulators in preventing button shedding indicated that NAA at 20 ppm was the most effective followed by 2, 4-D, 10 ppm, to obtain maximum yield benefit without loss of quality.

981. VOLETI, S.R.; SHIVASHANKAR, S. and RAJAGOPAL, V. 1991. Comparison of physiological and biochemical parameters of coconut hybrid seedlings. *J. Plantn Crops* 18(Suppl.): 104-107. (CPCRI, Kasaragod, Kerala).

Annual rate of leaf production, leaf area, leaf dry weight, increase in height and girth of four year old seedlings of MYDxWCT were higher than those of CODxWCT and MODxWCT. Activities of nitrate reductase and malate dehydrogenase were higher in MYDxWCT whereas that of acid phosphatase and glutamic-oxalic acid transaminase were more in CODxWCT.

## 12. SOILS AND NUTRITION

982. ANILKUMAR, K.S. and WAHID, P.A. 1989. Impact of long term inorganic fertilization on soil nutrient availability and nutrition of coconut palm. *Oleagineux* 44(6): 281-284. (Radiotracer Laboratory, KAU, Trichur 680 654, Kerala).

Changes in soil chemical properties and nutrient availability as a result of 22 years of regular annual application of ammonium sulphate, superphosphate and muriate of potash at varying levels were evaluated in a factorial fertilizer experiment in an acidic alfisol. Erosion of soil Mn fertility along the root zone profile due to drop in pH and accumulation of sulphate even at 75-100 cm were noticed in superphosphate receiving plots. Application of muriate of potash resulted in the increase of available K as well as organic matter content of the soil. Soil enrichment of P and S did not enhance the uptake of these nutrients by the palm. On the other hand, superphosphate application improved the Ca content of the soil and Ca of the palm. The results indicate that regular application of ammonium sulphate and superphosphate can adversely affect the K retention in the soil.

983. ASHRAF, P. MUHAMMED. 1990. Studies on magnesium dynamics in coconut growing soils and its impact on coconut nutrition. M.Phil. dissertation. Mangalore University, Mangalore. 130p. (CPCRI, Kasaragod, Kerala).

The main theme of the thesis is a) balanced amount of Mg should be maintained both in soil and tissues, otherwise it would tend to interfere with the nutrition of most important elements like K and N thereby altering K-Na balance in the plant which primarily governs the yield. b) Since Mg has given negative relationship with K, Na and yield strongly suggesting the antagonistic mechanism of Mg

on K and Na. Therefore a judicious manipulation of soil and tissue Mg needs to be attempted in order to achieve the maximum productivity.

984. BADRINATH, H.B. LINGAIAH; GURUPRASAD, T.R. and GOWDA, N.A. JANARDHANA. 1989. Soil constraints for coconut cultivation in Dakshina Kannada district (Karnataka) and suggestions for improvement. *Indian Cocon. J.* 20(1): 7-9 (Agric. Res. Station, UAS, Mangalore 575 002, Karnataka).

The soil analysis study of Dakshina Kannada district revealed that the soils are acidic in nature and salt content level is normal to critical. The major nutrients viz., organic carbon, available phosphorus and potassium do not show any major variation from taluk to taluk. In general soils are low in available potassium, calcium and magnesium which may be due to the high rainfall in the region. Regarding micronutrient status, the soils are low in zinc and boron, while iron, manganese and copper are adequate. The analysis of quality parameters of irrigation water shows that it is safe for use.

985. BARANWAL, V.K.; MANIKANDAN, P. and RAY, A.K. 1989. Crown choking disorder of coconut; a case of Boron deficiency. *J. Plantn Crops* 17(2): 114-120. (CPCRI Res. Centre, Mohitnagar, Jalpaiguri 735 101, W.B.)

Crown choking is a serious disorder of coconut and is taking a heavy toll of the crop, particularly young palms in Assam and West Bengal. The symptomatology of the disorder was studied and soil and leaf samples were analysed to determine the nutrient deficiency. It was found that the boron status of soil was much less in diseased area compared to that of healthy area. The concentration of boron was also less in the diseased palms in com-

parison to the healthy palms. The Ca/B ratio was much less in healthy palms of diseased as well as healthy area when compared to diseased palms. These observations along with the symptomatology and alleviation of the disease by application of borax confirm the possible role of boron deficiency in the crown choking disorder of coconut.

**986. BHUVA, H.P.; KATRODIA, J.S. and CHUNDAWAT, B.S. 1988.** Effects of different levels of NPK and their economics on coconut varieties under south Gujarat conditions. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988.* Abstracts of papers. p. 37. (GAU, Navasari Campus, Navasari 396 450, Gujarat).

An experiment on coconut was conducted at the Department of Horticulture, Gujarat Agricultural University, Navsari Campus, Navsari during the period from 1972 to 1986. The soil of the experimental plot was black with 61.21% clay, 22.17% silt and 16.60% sand, having 7.5 pH and 0.15 EC mmho/cm at 25°C. T x D and West Coast Tall were observed in the main plot. Six treatments of NPK fertilizers viz., two levels of nitrogen (750 and 1500 g N/palm) and three levels of potash (750, 1500 and 2250 g K<sub>2</sub>O/palm) and 750 g P<sub>2</sub>O<sub>5</sub>/palm were applied evenly in the sub-plot. The yield performance of different treatments was evaluated after obtaining stable yield from 1983 to 1986. T x D hybrid gave significantly higher yield than West Coast Tall. Application of 1500 g N + 750 g P<sub>2</sub>O<sub>5</sub> + 1500 g K<sub>2</sub>O per palm gave significantly higher yield in both T x D and WCT (12782 and 8729 nuts/ha) and it was the most economical dose which give a net ICBR of 1:16.8 and 1:11.3 in T x D hybrid and West Coast Tall respectively, under South Gujarat conditons.

**987. BIDDAPPA, C.C. and BOPAI AH, M.G. 1989.** Effect of heavy metals on the distribution of P, K, Ca, Mg and micronutrients in the cellular

constituents of coconut leaf. *J. Plantn Crops* 17(1): 1-9. (CPCRI, Kasaragod, Kerala).

The distribution patterns of P, K, Ca, Mg and micronutrients with special reference to heavy metal treatments were evaluated. The results indicated that the P distribution in organic acids, polar compounds, proteins and nucleic acids and polysaccharides was influenced by the heavy metals. However, the K content of lipids and pigments, organic acids, cellulose and insoluble residues was significantly altered due to heavy metal treatment. The Ca concentration in lipids and pigments and organic acids has been significantly depressed by heavy metals. A similar pattern of depression of Mg content has been recorded in nucleic acid, polysaccharides and organic acid fractions.

Among micronutrients, iron content in proteins, cellulose and insoluble fractions increased by heavy metals in general and due to Pb and Cd significantly in pigments. All the seven heavy metals increased the Mn content in polar compounds over control. Cd, Bi, Cr and Ba exerted profound increase in Zn distribution in polysaccharides and insoluble residues over control. There was no change in Zn concentration with lipids, pigments and organic acids. In respect of Cu there was noticeable change due to heavy metals in pigments, cellulose, polysaccharides and insoluble residues. Cu content increased insoluble residues and pigments.

**988. BIDDAPPA, C.C.; BOPAI AH, M.G. and KHAN, H. HAMEED. 1988.** Nutrition of hybrid coconut. *In: National Symposium on Coconut Breeding and Management, KAU, Trichur, Nov. 23-26, 1988.* Abstracts of papers. p. 32-33. (CPCRI, Kasaragod, Kerala).

Comparatively, removal of NPK and other nutrient elements by hybrid varieties appear to be lesser than the tall varieties of coconut as revealed by the analysis of components. This

is supported by the results of 15 year old manurial trial with WCT and three hybrids at CPCRI, Kasaragod. These results have shown that theoretically (M-B model) just to realise 50 per cent of maximum yields COD x WCT and WCT x COD require only 75:75:150 and 144:144:288 g N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O respectively and to obtain 87.5 per cent of the maximum yield, the fertilizer application can be tailored to two third quantity.

Nutrient relationship to yield of coconut has shown good indications. Nitrogen content of all the leaf ranks (except 6) significantly related to yield in which leaf No. 1 was showing highest correlation. The K values of all the leaves (except No. 1) are significantly related to yield. The study on chemical potential in the palm and their relationship to the yield has indicated positive correlation of leaf K and Mg with coconut yield.

The D x T among the available hybrids registered to be efficient user of nutrients in the cellular fractions of the constituents.

989. BIDDAPPA, C.C. and KHAN, H. HAMEED. 1985. A note on the heavy metal status of coconut growing soils of Kerala. *J. Indian Soc. Soil Sci.* 33(4) : 915-916. (CPCRI, Kasaragod, Kerala).

Authors have studied root(wilt) disease and various physiological disorders in relation to imbalanced status of nutrients and heavy micronutrient deposits of the soils.

990. BIDDAPPA, C.C.; KHAN, H. HAMEED; JOSHI, O.P. and MANIKANDAN, P. 1987. Effect of root feeding of heavy metals on the leaf concentration of P, K, Ca and Mg in coconut (*Cocos nucifera* L.). *Pl. Soil* 101(2) : 295-297. (CPCRI, Kasaragod, Kerala).

The effect of supplying various metals viz., Pb, Cd, Al, Bi, Cr, Cu and Ba to the roots of coconut palms on the P, K, Ca and Mg concentration in the leaves of coconut palms

was investigated. The results showed that compared with the control the amount of leaf P was reduced by all the metals. The K concentration in the leaves was reduced by Al, Cd and Ba but increased by Bi and Cr. Leaf Ca concentration was decreased by Al and Pb treatments and increased by Cd, Cr, and Ba. The amount of Mg in the leaves was low in palms receiving Al and Cr but enhanced by Pb.

991. BIDDAPPA, C.C., KHAN, H. HAMEED; JOSHI, O.P. and MANIKANDAN, P. 1988. Effect of heavy metals on micronutrient nutrition of coconut. *Curr.Sci.* 57(20) : 1111-1113. (CPCRI, Kasaragod, Kerala).

Fifteen-year-old palms were fed, via the roots, with Pb, Cd, Al, Bi, Cr and Ba for periods ranging from 49 to 87 days. Leaf concentrations of Fe, Mn, Zn and Cu generally increased by heavy metal treatment, and significantly higher concentration of these four nutrients were observed after feeding with Cr, Bi, Ba and Pb respectively.

992. BIDDAPPA, C.C.; NAGARAJAN, M. and RETHINAM, P. 1990. Heavy metal pollution through cement dust in coconut ecosystem. *J.Plantn Crops.* 18(1) 58-62. (CPCRI, Kasaragod, Kerala).

The paper deals with the studies on the extent of heavy metal pollution of soil and vegetation through loading capacity of cement dust emitted from cement factories at ~~two~~ places in Karnataka, India. Among the biotoxic metals that polluted these areas Ni, Sb, Cr, Co, Pb and Cd were prominent. It is concluded that the vegetation around the factories might suffer from metal toxicity.

993. BOPAIAH, M.G. and BIDDAPPA, C.C. 1987. Studies on the nitrogen release pattern by ureaform and coated fertilizers in acid soils. *J.Plantn Crops.* 15(1) : 42-46. (CPCRI, Kasaragod, Kerala).

The results of investigation conducted on the coastal sand, red sandy loam and laterite soils with four slow release nitrogen source for their nitrogen release pattern in the laboratory have been reported. Ureaform recorded low exchangeable ammonium and urease activity than all other slow release sources used. The ureaform released ammonical, nitrate and urea nitrogen for more than 105 days irrespective of the soils. In laterite, urea and neem cake coated urea registered significantly high nitrate nitrogen. In all the soils, nitrate nitrogen was recorded upto 45 days only. Neem cake blended urea and urea blended with neem cake and coal tar showed higher nitrate nitrogen.

994. CECIL, S. ROBERT. 1984. Effect of N, P, K, Ca and Mg on leaf nutrient content and yield of young coconut. *In: Symposium on Plantation Crops, 6th, RR11, Kottayam, Dec. 16-20, 1984. Proceedings of PLACROSYM VI. Edited by M.R. Sethuraj and others. p.331-351. (CPCRI (RS), Kayangulam, Kerala)*

The effect of graded doses of nitrogen, phosphorus, potassium, calcium and magnesium on the yield, yield attributes and leaf nutrient concentration of young coconut palms of West Coast Tall variety is presented hereunder:

Application of all the nutrients except phosphorus increased the concentration of these nutrients in the leaf. However, the effects of nitrogen and potassium were significant only in the initial years. Applied phosphorus had ~~only~~ marginal influences on leaf phosphorus. Higher levels of nitrogen, phosphorus and potassium had no significant influence over the lower levels on the yield and yield attributes. The main effect of magnesium was significant on the yield and yield attributes. The direct and indirect effects of soil and leaf nutrient concentrations on the yield are also discussed.

995. CECIL, S. ROBERT. 1988. Calcium and magnesium nutrition of coconut palm. *In: National Symposium on Coconut Breeding and*

*Management, KAU, Vellanikkara, Trichur, Nov. 23-26. Abstracts of papers. P.34-35. (ICAR Research Complex for Lakshadweep (CPCRI), Minicoy, Lakshadweep).*

Crop removal studies suggested that the quantitative requirements of coconut for Ca and Mg are much higher than that of P. Calcium is mainly concerned for the proper growth and functioning of stem and leaves of the palm rather than its productivity of nuts. Instances of Ca deficiency conditions of the palm were rarely found and the direct effects of Ca on growth or yield were seldom reported except when the leaf Ca levels were extremely low. The critical level of 0.3 per cent Ca (frond 14) appears to have a broader applicability as a diagnostic aid for regulating the Ca nutrition of the palm. Intensive liming is not needed for the management of the palm. Nevertheless, regulated additions of Ca through Ca bearing fertilizers like rock phosphate, super phosphate or light additions of lime may be followed for supplying the Ca requirement of the palm.

Magnesium is observed to be one of the limiting nutrient element in the nutrition of the palm, particularly on seedlings and young palms. Deficiency of Mg is common on soils that are poor in this element, particularly on acid sandy soils, and is also induced by high K/Mg ratio. Magnesium saturation of 15-20% of the exchange complex and exchangeable Mg/K ratio of 2.0 to 2.5 in the soil, and a foliar level of 0.2% Mg in frond 14 may be considered as critical for regulating the Mg nutrition of the palm. Application of Mg salts, usually epsom/kieserite, corrects the deficiency conditions faster while dolomite may be used for long term remedy or prevention. The increase in yield of nuts on correction can be as high as 40 per cent. Regular Mg addition in the form of magnesium sulphate (hydrated) at the rate of 500 g Mg/adult palm/year from the time of field planting on a Mg deficient acid sandy soil in the West Coast of Kerala had

increased all the growth parameters at a highly significant level, reduced the pre-bearing age of the palm by 9.1 months. However, the dose of Mg may be regulated based on the extent of limitation of Mg and the exchangeable Mg/K ratio of the soil and also the foliar Mg levels of particular situation. The incidence of coconut root(wilt) disease did not show any relation with Ca or Mg nutrition of the palm. However, correction of Mg deficiency showed more favourable response on growth and yield of diseased palms compared to healthy.

996. CECIL, S. ROBERT and PILLAI, N.G. 1978. Role of boron in coconut nutrition. *Indian Cocon. J.* 8(9): 1-3. (CPCRI (RS), Kayangulam, Kerala).

Boron is considered to be one of the essential micronutrients for plant growth. The effect of boron on certain physiological and pathological problems was studied in various parts of the world. The crown rot disease seen in N.E. India is believed to be caused by boron deficiency. In Kerala 12% of coconut soils are reported to be deficient in boron. This suggests a vigilant watch on the occurrence of crown rot of young palms. Timely application of 100-250 g of borax could save the affected palms.

997. CECIL, S. ROBERT; PILLAI, N.G.; MATHEW, A.S. and KAMALAKSHYAMMA, P.G. 1978. A note on the nutrient element ratio in relation to foliar yellowing in coconut palm. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Nov. 20-23, 1978. Proceedings of PLACROSYM I.* Edited by E.V. Nelliath and others. p.371. (Abstract) (CPCRI (RS), Kayangulam, Kerala).

The major nutrient composition of coconut leaves from healthy palms and from palms affected by foliar yellowing was studied and the role of major nutrients and their ratio on the incidence of yellowing was evaluated. The N and P contents did not differ between healthy and affected palms. The K content was higher in affected palms while the Ca and

Mg contents were higher in healthy palms. Evaluation of nutrient element ratio indicated that the palms affected by foliar yellowing were in a state of unbalanced nutrition, particularly among the major cations, with wider K/Ca, K/Mg and Ca/Mg ratios compared to healthy palms.

998. CHATTOPADHYAY, P.K. and HASAN, M.D. ABU. 1986. Growth of young coconut (*Cocos nucifera*) palm variety, local tall at different levels of Nitrogen, Phosphorus and Potassium. *Env. & Ecol.* 4(4): 671-674. (Dept. of Horticulture, BCKVV, Kalyani, Nadia, W.B.)

An experiment was conducted to find out the effect of different levels of N, P and K on the growth of local tall coconut variety at its pre-bearing stage in the alluvial soils of West Bengal. The height of the plant increased significantly with nitrogen nutrition and was maximum at 1000 g N/plant. Girth was influenced with potassium nutrition. For leaf production the effect of nitrogen and potassium was more pronounced compared to phosphorus. Better growth of young palms was possible with 1000 g N and 1250 g K<sub>2</sub>O per plant but the different levels have same effect.

999. CHATTOPADHYAY, P.K. and HASAN, M.D. ABU. 1987. Leaf nutrient concentration in coconut variety, east coast tall following fertilizer application. *Indian Agric.* 31(3): 191-198. (Dept. of Horticulture, BCKVV, Kalyani, Nadia, W.B.)

An investigation was carried out to find out leaf nutrient composition of young coconut palm variety local tall under the influence of NPK fertilization. The levels of fertilizers were N-500, 1000, 1500 g; P-250, 500, 540 g and K-750, 1250 and 1750 g/palm/year.

The nitrogen content in leaf showed significant variation with the increasing level of the nutrient. Application of phosphorus also influenced the leaf nitrogen concentration. Leaf phosphorus content was influenced very much

due to application of phosphorus and was maximum at P<sub>2</sub> level of the nutrient. Similar to nitrogen and phosphorus the leaf potassium concentration also increased significantly at both the time of sampling with increasing potassium level. Interaction effect although showed variation in the leaf nutrient composition did not reach the significant level with the majority treatment.

1000. CLARSON, D.; DAMODARAN, C. and GHOUSE, L. MOHAMED. 1986. Response of magnesium and borax on coconut yield. *Indian Cocon. J.* 16(11): 6-7. (Soil Test Laboratory, Nagercoil, T.N.).

An experiment was conducted at Periyavilal of Kanyakumari district of Tamil Nadu to find out the requirements of micronutrients in coconut nutrition with twenty four treatments comprising of six micro elements each with four levels. Among all the trace elements tried, the applications of magnesium @ 15 kg/ha (i.e., 100 g/palm) and borax - @ 5 kg/ha (i.e., 50 g/palm) were found to have the maximum response on coconut yield which recorded significantly higher than the other treatments.

1001. CLARSON, D.; DAMODARAN, C. and GHOUSE, L. MOHAMED. 1988. Optimum NPK fertilizer doses to coconut for maximum yield and maximum rate of return. *Indian Cocon. J.* 19(5): 5-9. (Dept. of Soil Science, TNAU, Coimbatore, T.N.).

In order to evolve site specific optimum fertilizer recommendations to coconut for maximum yield and maximum rate of return over the blanket recommendations, six field experiments were conducted at the major coconut soils based on Colwen's methodology. The results indicated that the optimum dose of nitrogen to coconut to get the maximum rate of return ranged from 0.9 to 2.0 kg per tree per annum. The optimum doses of phosphorus and potassium ranged from 0.12 to 0.30 and 1.4 to 1.8 kg per tree per annum,

respectively.

1002. DEB, D.L.; SACHDEV, M.S. and \*WAHID, P.A. 1977. Some aspects of soil fertility problems of major coconut growing acid soils of Kerala. *J. Indian Soc. Soil Sci.* 11:260-276. (\*CPCRI, Kasaragod, Kerala).

The chemical composition of soil and the available nutrient status were explored as a guide in establishing the nutritional disorders in coconut palm in major coconut growing acid soils of Kerala. The general nutrient index for organic carbon and available P and K was average. In general, there was not much difference in available P, K, Ca, Mg, Zn, Cu, Fe, Mn, Al, pH and organic C in the soils representing the healthy and the diseased tracts. The total and available P, K, Ca and Cu were low in all the soils. The total Mg content was low in all the soils but its availability was fairly high. The total and available Zn and Fe in all the soils were high leaving few exceptions. The total Mn content was high but the available Mn content was low, in general, in all the soils.

1003. DWIVEDI, R.S.; RAY, P.K. and NINAN, S. 1981. Studies on the methods of inorganic nutrient application in coconut. *Pl. Soil* 63(3): 449-456. (CPCRI (RS), Kayangulam, Kerala).

KH<sub>2</sub><sup>32</sup>PO<sub>4</sub> labelled single superphosphate, and <sup>86</sup>Rb<sub>bc</sub> were applied by plant treatment or soil placement to coconut palms, (cv.) West Coast Tall. Application through the cut ends of roots was the most efficient plant treatment since <sup>32</sup>P and <sup>86</sup>Rb<sub>rb</sub> were detected in 10-m palms after 4 h. Label from solutions injected into the stem, poured into the leaf axils, or bathing the growing root tips appeared after 8, 12 and 18 h, respectively. Label was recovered within 7 days of fertilizer placement in 1-cm-wide, 10 to 70 cm deep holes bored around the tree in concentric trenches 0.5 and 1m from the tree, fertilizer applied to radiating strips of excavated roots immediately around the

stem base, and fertilizer applied in a 1 to 2 m wide basin excavated around the stem. Although not the fastest method, application in trenches was the most efficient of the soil methods.

1004. GHOSH, S.P.; NAIR, G.M. and PILLAI, N.G. 1987. Productivity and nutrient uptake by cassava in association with four perennial species. *Trop. Agric.* 64(4): 233-236. (CTCRI, Trivandrum, Kerala).

Growth, nutrient uptake and productivity of cassava cv. H 1687 grown in association with 4 perennials (coconut, banana cv. Njalipoovan, eucalyptus and leucaena) were investigated in Kerala, India, during the first 2-year growth period (1983-1985) of the perennials. Cassava was harvested after 10 months. Dry matter and production, uptake of N,P,K, Ca and Mg and tuber yield (47.8 t/ha in the 1st year) of cassava were highest under banana. A reduction in tuber yield was noticed under eucalyptus and leucaena, (20.9 and 23.8 t/ha, respectively, in the 1st year), which was more conspicuous during the 2nd year, mainly due to moisture stress. The shade effect of the perennials on cassava was maximum under eucalyptus. As there were no marked differences in the concentration of individual nutrients in the respective plant parts of cassava sampled from the different crop associations, the difference in total nutrient uptake was mainly attributable to the significant differences in the total dry matter production of cassava in the 4 associations.

1005. HASSAN, A. and CHATTOPADHYAY, P.K. 1989. Influence of fertilizer application on the available nutrient status of the soil of coconut orchard. *Indian Agric.* 33(3): 169-174. (Dept. of Horticulture, BCKVV, Kalyani, Nadia, W.B.).

The experiment was conducted to find out the available soil nutrient status of the young coconut palm orchard following N, P and K application. The levels of fertilizers were

N 500, 1000, 1500 g : P<sub>2</sub>O<sub>5</sub> 500, 750 g and K 750, 1250 and 1750 g/palm/year.

Soil nutrient status at two depths before application of fertilizer showed maximum concentration of N and K mainly in the upper depth (0-25 cm). The N content in the soil did not improve much although both P and K content of soils improved appreciably after first split application of fertilizers. The soil analysis after second split application of fertilizers also showed negligible improvement in soil N status. Available soil P content was maximum at 25-50 cm depth while available K was recorded maximum in the first depth (0-25 cm).

1006. JOSE, A.I.; KRISHNAKUMAR, N. and GOPI, C.S. 1988. Yield prediction in coconut based on foliar nutrient levels. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.36.* (College of Horticulture, KAU, Trichur, Kerala).

Standardisation of leaf tissue for foliar diagnosis of N, P and K in relation to yield was carried out in WCT coconut palms of varying fertility gradients grown under rainfed condition of the Southern, Central and Northern regions of Kerala. Yield of the palms was significantly correlated with N per cent of the leaf lamina of 2nd, 10th and 14th leaves, the highest coefficient of partial correlation being registered by the yield and P per cent of leaf lamina of the above three leaf positions were not significant. The coefficients of partial correlation between yield and K per cent of leaf lamina of leaf positions 2 and 10 were significant, the highest value being recorded by the 10th leaf. The optimum contents of N and K in the 10th leaf for maximum yield were 2.9 and 1.8 per cent respectively. The leaf lamina of leaf position 10 is recommended as the best tissue for foliar diagnosis in coconut.

Regression models are suggested to

predict the yield with an accuracy of 86 per cent utilizing nitrogen, phosphorus and potassium content of the leaf lamina of 10th leaf and the number of leaves retained by the palm.

**1007. JOSE, A.I.; VENUGOPAL, V.K.; SUSHAMA, P.K.; GOPI, C.S. and SAIFUDEEN, M. 1985.** Micronutrient status of soil and leaf of coconut palms growing on reclaimed marshy soil. *Agric. Res. J. Kerala*. 23(1): 90-92. (College of Horticulture, KAU, Trichur, Kerala).

Soil and leaf samples, collected from 30 to 40 year old palms of the cv. West Coast Tall, were assessed for Fe, Mn, Zn, Cu and B levels. The data are tabulated. In the case of Fe, Mn, and Cu the mean values were well above the critical limits, Zn was within the prescribed level for this element, but the mean value for B was below the critical level (12-40 ppm).

**1008. JOSHI, O.P.; KHAN, H. HAMEED.; BIDDAPPA, C.C. and MANIKANDAN, P. 1985.** Effect of coir dust on mineralisation of urea nitrogen in coconut growing red sandy loam soils (*Arenuc paleustults*). *J. Plantn Crops*. 13(2): 88-95. (CPCRI, Kasaragod, Kerala).

Laboratory incubation studies revealed that blending urea with retted and unretted coir dust resulted in inhibition/immobilization of urea nitrogen. Blending of urea with unretted coir dust in 1:2 proportions resulted in accumulation of  $\text{NH}_4^+\text{-N}$  and retted coir dust in the same proportion led to lowest production  $\text{NH}_4^+\text{-N}$ . During the incubation period  $\text{NO}_3\text{-N}$  appeared to be withdrawn from the system in urea blended with unretted coir dust (1:1) treatment, whereas its production was lower in the case of other combinations of urea with retted (1:1 and 9:1) and unretted coir dust (9:1) compared to urea. Production of total mineralised nitrogen was consistently lowest when urea was blended with retted coir dust (1:1). Unretted coir dust (1:1) produced lower mineralised nitrogen than urea alone and the

other blendings with lower proportions of retted and unretted coir dust (9:1) showed intermediate behaviour. The results indicated the usefulness of blending urea with coir dust for controlled and gradual release of urea nitrogen. It has a bearing in the fertilizer programmes for perennial plantation crops largely grown in soils prone to heavy leaching losses.

**1009. KAMALADEVI, C.B. and VELAYUTHAM, M. 1977.** Leaf nutrient concentration in coconut following fertilizer application. *Philipp. J. Cocon. Studies* 2(4): 26-33. (CPCRI, Kasaragod, Kerala).

Monitoring nutrient concentration in the 14th leaf immediately after NPK application to the soil indicated that maximum concentration was obtained on the 5th day after application for N and P, and on the 2nd day for K. The increase in N, P and K concentration in unopened leaves was 21-36, 14-25 and 27-60%, respectively; similar increases in the 14th leaf were 19-32, 29-47 and 32-51%, respectively. N and P values were similar to the critical levels fixed by Fremond (Hca 37,1831) whereas Ca was lower and K, Fe and Mn were much higher. N, P, Ca, Mg, Fe and Mn were higher in the oldest green leaves but the reverse was noted for K and Cu. Foliar concentrations did not reflect yield differences between genotypes.

**1010. KAMALADEVI, C.B.; VELAYUTHAM, M. and HARIDASAN, M. 1983.** Soil and leaf analyses in relation to the nutrition of high yielding coconut genotypes. *In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976*, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.115-119. (CPCRI, Kasaragod, Kerala).

Seasonal changes in the nutrient composition of index leaf and available nutrient status of a ten year old coconut plantation on acid sandy loam soil were evaluated in three high yielding coconut genotype (West Coast Tall, Tall x Dwarf, and Dwarf x Tall) growing

under three fertilizer levels. Seasonal changes in leaf nutrient status confirmed that the fourteenth leaf could be taken as the index leaf under the local condition. Available K was a limiting nutrient which was reflected in deficient K concentration in leaf of control plots. An inverse relationship between K and Mg content of leaf was observed. Leaf concentration of N was not significantly influenced by fertilization. Even at the highest level of fertilizer application it was below the critical limit proposed by IRHO. However, yield data indicated that the critical limit could possibly be lowered to suit the West Coast of India conditions. No significant variation was observed in P content of leaves due to fertilizers or genotypes. Fixation of P in the soil appeared to have accentuated during monsoon months. N.P.K. fertilization increased the concentrations of Mn, Zn, Fe and Cu in the leaf while that Ca, S, Fe, B and Mo were unaffected.

1011. KAMALADEVI, C.B.; WAHID, P.A.; PILLAI, N.G. and SANKARANARAYANAN, M.P. 1976. Effect of NPK fertilizers on trace element nutrition of three coconut genotypes. *J. Plantn Crops* 3(1): 11-13. (CPCRI, Kasaragod, Kerala).

The trace element status of the soil and leaves of three coconut genotypes (viz., West Coast Tall, Tall x Dwarf and Dwarf x Tall) was studied for three levels of NPK fertilizer combinations viz., no fertilizer ( $F_0$ ), 0.5 kg N and 1.0 kg  $P_2O_5$  ( $F_1$ ) and 1.0 kg  $P_2O_5$  and 2.0 kg ( $K_2O$ )/palm/year ( $F_2$ ). The lowering of the soil pH due to fertilizer application enhanced Mn, Fe and Al availability but only Mn uptake actually was increased as evidenced by leaf Mn levels of 426,765 and 842 ppm for  $F_0$ ,  $F_1$  and  $F_2$  fertilizer treatments, respectively. As for the genotype, there was little difference in trace element requirements among the three. There was, however, increased requirements for Zn and Cu in response to increased fertilizer application as evidenced by leaf concentrations of 13.2, 29.0 and 32.5 ppm in the case of

Zn and 11.5, 20.3 and 22.8 ppm in the case of the Cu for  $F_0$ ,  $F_1$  and  $F_2$  fertilizer applications, respectively.

1012. KAMALAKSHYAMMA, P.G. and PILLAI, N.G. 1988. Role of magnesium in coconut nutrition. *Indian Cocon. J.* 11(3): 1-2 (CPCRI, (RS), Kayangulam, Kerala).

Authors describe the role of magnesium in a healthy palm which gives a better yield. Magnesium being only metal constituent of chlorophyll consists about 2.7% of chlorophyll molecule, representing approximately 10% of the total leaf Mg. It helps as a carrier in the transport of phosphorus in plants.

1013. KHAN, H. HAMEED; BIDDAPPA, C.C. and JOSHI, O.P. 1985. A review of Indian work on phosphorus nutrition of coconut. *J. Plantn Crops* 13(1): 11-21. (CPCRI, Kasaragod, Kerala).

Though phosphorus is a very important nutrient for coconut, the information presented suggests that phosphorus is normally not a limiting nutrient for coconut production. More so, adult palms have not been found to be much benefitted by annual P applications. Fertilizer experiments have shown that the P needs are low, responses slow and inconsistent.

Soil P levels are to be relied more than foliar levels in judging the P needs of coconut groves. The authors suggest various guidelines for future investigations on P nutrition.

1014. KHAN, H. HAMEED; BIDDAPPA, C.C.; JOSHI, O.P.; MANIKANDAN, P. and GOPALASUNDARAM, P. 1986. Fertilizer recommendation for coconut based on Mitscherlich-Bray equation. *J. Plantn Crops* 14(1): 65-67. (CPCRI, Kasaragod, Kerala).

M-B equation has been employed for suggesting site specific fertilizer application to coconut. The response function for yield was found to be linear for West Coast Tall (WCT) and curvilinear for WCT x Chowghat Dwarf

Orange (CDO) and CDO x WCT. The theoretical maximum yield under this experiment was found to be 83.4, 80.5 and 61.4 nuts/palm/year for WCT, CDO x WCT and WCT x CDO. To realize 50% of maximum yield CDO x WCT and WCT x CDO require 75:75:140 and 144:144:225 respectively of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/palm/year. To attain 93.75% of maximum yield CDO x WCT requires 500:500:1000 and WCT x CDO 660:660:1320 g N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/palm per year. Calculation of efficiency factors for soil and fertilizer form of nutrients indicate that soil form of nutrients are more efficient than added form of nutrient except for N in the case of hybrids.

**1015. KHAN, H. HAMEED.; BIDDAPPA, C.C.; NAGARAJAN, M.; THOMAS, GEORGE, V. and CECIL, S. ROBERT.** 1990. Residual effect of long term phosphorus application on soil and plant nutrient contents, microbial association and yield of coconut. *In: Symposium on Plantation Crops, 9th, CCRI, Chikmagalur, Dec. 5-7, 1990. Abstracts of papers. p.5. (CPCRI, Kasaragod, Kerala).*

Skipping of phosphorus application to adult coconut palms has resulted in reduction of soil available P from 43.88 ppm (0-90 cm feeding zone-1975) to 12.72 ppm (1989) over a period of 14 years. Application of P at two levels showed no advantage in further enhancement of P nutrition and yield. Similarly skipping of P application for 14 years also had no deleterious effect on P nutrition and yield of palms indicating residual effectiveness of phosphorus. Interestingly VA mycorrhizal infection was more in the P-0 treatment (79.3%) compared to P-1 (52.1%) and P-2 (47.9%). Population of P solubilizing bacteria was also higher in P-0 treatment indicating the involvement of microbial population in P nutrition of coconut. The mean yield of the palms (1989) viz., 109.07, 102.36 and 108.71 nuts, palm year in P-0, P-1 and P-2 treatments respectively and the cumulative yield for four years did not

show significant differences among treatments. It was indicated that residual phosphates of 10 ppm in 0-90 cm depth in the basin could sustain adequate P nutrition and normal yields for 14 years. Soil available phosphorus status of 10-12 ppm maintained sufficient level of P in the coconut palms.

**1016. KHAN, H. HAMEED.; GOPALA-SUNDARAM, P.; JOSHI, O.P. and NELLIAT, E.V.** 1986. Effect of NPK fertilization on the soil nutrition and yield of three coconut genotypes. *Fertilizer Res. 10(2): 185-190. (CPCRI, Kasaragod, Kerala).*

Annual application of NPK fertilizers to coconut on red sandy loam soils resulted in increase in mineralizable N, but in a marked increase in available P and K. Plant N levels, however, reflected the improved N nutrition but did not reach sufficiency levels found elsewhere. An available P status of 15 ppm in control plots kept leaf P at insufficiency levels. P fertilizers did not increase the P content of leaves, K fertilizers raised the K leaf content to sufficiency levels. Doubling the M<sub>1</sub> fertilizer rates of 500 g N, 200 g P and 130 g K per palm per year had no effect on N, P and K levels in the palm leaves. Changes in K levels of the leaves had antagonistic effects on leaf Mg ( $r=-0.68^*$ ) and leaf Na ( $r=-0.87^{**}$ ). As this effect brings leaf Mg close to deficiency values palms receiving K might need additional Mg as well. The findings and interpretation of soil and leaf analysis data were confirmed by tree yield responses to application of NPK fertilizers. Genetic differences between palms in their response to levels of nutrient supplies were apparent. The CDO x WCT hybrid outyielded the high yielding WCT variety especially when NPK was given at the M<sub>1</sub> level. The response in yield to applied fertilizers was linear for WCT and curvilinear for the hybrids CDO x WCT and WCT x CDO.

**1017. KHAN, H. HAMEED; JOSHI, O.P. and**

BIDDAPPA, C.C. 1984. Absorption, desorption and selective distribution of phosphorus and potassium in relation to soil fertility potential in major coconut growing soils of India. In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited By K.V.A. Bavappa and others. p.411-424. (CPCRI, Kasaragod, Kerala).

Sixteen major coconut growing soils of India representing laterite, red sandy loam, river alluvium and coastal sand were evaluated for absorption, desorption and selective distribution properties with special reference to Neubauer seedling test. The absorption of P and K obeyed the Freundlich Adsorption Isotherm (FAI) :  $x/m = KC^{1/n}$  where  $x/m$  is the amount ( $\mu\text{g}$ ) of P or K absorbed per g of soil; C, the equilibrium concentration of P or K in  $\mu\text{g}/\text{cm}^3$ ; and K and  $1/n$ , are constants. The magnitude of the constants, K and  $1/n$ , are related to the differences in P and K absorption characteristics of different soils. Generally, the desorption of P is slow, whereas about 90 per cent of applied K is extracted in the first two extractions. Selective dissolution studies showed that the reductant soluble P and  $\text{HNO}_3$  extractable K are the dominant P and K fractions respectively in these soils. The biologically extractable P and K (Neubauer seedling test), a measure of the fertility potential of the soils, were in the range of 0.013, 1.181 mg P/100 g soil, and 0.85 to 3.45 mg K/100 g soil respectively. Association between the FAI constants, the selective distribution of and the biologically extractable P and K (Neubauer seedling test) a measure of the fertility potential of the soils, were in the range of 0.013, 1.81 mg P/100 g soil, and 0.85 to 3.45 mg K/100 g soil respectively. Association between the FAI constants, the selective distribution of and the biologically extractable P and K are discussed based on the simple correlation coefficients among them.

1018. KHAN, H. HAMEED;

SANKARANARAYANAN, M.P.; GEORGE, M.V. and NARAYANA, K.B. 1983. Effect of phosphorus skipping on the yield and nutrition of coconut palm (*Cocos nucifera* L.). *J. Plantn Crops* 11(2): 129-134. (CPCRI, Kasaragod, Kerala).

In trials with 22 year old West Coast Tall palms, growing on red sandy loam soil, skipping P application resulted in the reduction of soil available P from 84 to 59 ppm at 0-30 cm depth and from 24 to 13 ppm at 30-60 cm depth in the palm basins. Neither a reduction in soil available P or an increase consequent to fertilizer application at 2 levels for the past 6 years significantly influenced foliar P levels and yields. The possibility of skipping P application in soil where available P is around 24 ppm at 30 to 60 cm depth is outlined. The usefulness of foliar P levels as a guide to fertilizer application is questioned.

1019. KHAN, H. HAMEED; SANKARANARAYANAN, M.P.; JOSHI, O.P., GEORGE, M.V. and NARAYANA, K.B. 1985. Comparative efficiency of selected phosphates as P carriers for coconut (*Cocos nucifera* L.) *Trop. Agric.* 62(1): 57-61. (CPCRI, Kasaragod, Kerala).

The results of a field experiment conducted for six years on laterite soil showed that single superphosphate, ammonium phosphate, nitrophosphate and rock phosphate had similar effects on the yield of nuts palm<sup>-1</sup> yr<sup>-1</sup>. However, when percentage yield increase over pre-treatment yield was computed, rock phosphate proved best, followed by ammonium phosphate. Regression analysis revealed an optimum interaction between soil available P and leaf P for rock phosphate. The soil available P increased with the increase in the levels of P applied. Nitrophosphate increased the soil available P to a maximum, followed by ammonium phosphate, single superphosphate and rock phosphate. Fertilizer-P application generally reduced soil pH which was most marked with ammonium phosphate. The

treatments showed marginal mobility of P to the subsoil which has been attributed to mechanical movement as a result of cultural operations in the coconut basin. Higher levels of applied P influenced the leaf P values which were not reflected in the yield. Costs of fertilizer indicated that rock phosphate as a P-carrier is cheapest.

1020. KHAN, H. HAMEED; SANKARANARAYANAN, M.P. and NARAYANA, K.B. 1978. Characteristics of coconut soils of India; 1. morphology, some physico-chemical characteristics and taxonomy. In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p.54-79. (CPCRI, Kasaragod, Kerala).

On the West Coast of India, coconut is grown on laterites, coastal sand and red sandy loam, on the East Coast on deltaic alluvium, coastal sandy areas, and on localised patches of red and black soils in the interior areas. The morphological and some of the physiochemical characteristics of typical coconut growing soils from different agro-climatic regions of India have been discussed. The soils studied can be classified under Alfisols, Ultisols and Vertisols and classification upto subgroup level has been attempted under 'Soil Taxonomy'.

1021. KHAN, H. HAMEED; SURESH, K.K. and BIDDAPPA, C.C. 1988. Preliminary N, P and K foliar DRIS norms for coconut. *Madras Agric. J.* 75(3-4): 105-108. (CPCRI, Kasaragod, Kerala).

The efficiency of predicting nutrient imbalances and deficiencies in coconut was tested using the Diagnosis and Recommendation Integrated System (DRIS) which utilizes the ratio between tissue nutrient concentrations rather than the concentration per se; DRIS produces a more accurate diagnosis of imbalances than critical concentration studies. Plant samples were collected from the 14th

leaf (diagnostic leaf) in a population of 183 palms. Palms yielding less than 35 nuts/palm annually were considered low-yielding, and those producing more than 35 nuts/palm annually were considered a high-yielding, i.e., a desirable population. Coconut leaf norms were formulated for different forms of expression for N, P and K. A marked N deficiency was noted and was confirmed by experimental data. Data are also tabulated on other nutrients in the low-yielding and high-yielding populations.

1022. LOUIS, I. HENRY. 1980. The how and why of manuring the coconut palm. *Indian Potash J.* 5(2): 2-7. (RARS, TNAU, Veppankulam, T.N.)

In soils with high deficiency of potassium the dosage of potash may be increased by 50%. Normally the effect of fertilizer application in areas where no monsoon periods prevail and particularly on sandy soil, the fertilizer may be applied at six monthly intervals for greater efficiency and utilization. Split doses of fertilizers (1/3 in April-May and 2/3 in September-October) has resulted in the increase of 12 nuts per palm over single annual dose. Applying the fertilizer in 4 monthly intervals are now recommended for increasing the efficiency.

Normally the effect of fertilizer application to coconut will be perceptible only after 2½ to 3 years. But in soils having high percentage of nitrogen the beneficial effect from fertilizers will accrue even during the first year of manuring.

1023. LOUIS, I. HENRY. and KRISHNASWAMY, V. 1978. Preliminary observations on the effect of NPK nutrients on coconut seedlings in the laterite soil. In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar 20-23, 1978. Abstracts of papers. p.174. (RARS, TNAU, Veppankulam, T.N.).

The effects of three levels of NPK nutrients

on six different growth characters were studied in coconut seedlings of East Coast Tall raised under laterite soils.

During the second year of growth main effects of either N, P or K on all growth characters were not statistically significant. Other effects were also found not to reach the levels of significance except in the cases of N, P and N, K on the length of the petiole and N, P on the height of seedlings.

N<sub>1</sub> had definite effects on growth characters. Among the P and K levels P<sub>2</sub> (0.5 kg) and K<sub>2</sub> or K<sub>3</sub> (1.25 or 1.75 kg) had a telling effect. The effects of P levels on the length of petiole were at N<sub>2</sub> or N<sub>3</sub> levels but marked effects of P<sub>1</sub> with N<sub>1</sub> levels were also observed. N<sub>2</sub> and N<sub>3</sub> in conjunction with P<sub>2</sub> and P<sub>3</sub> produced significant increase of height for the seedlings.

During the third year of growth also substantial effects of the nutrients were clear. However, seedlings receiving N<sub>1</sub> P<sub>2</sub> K<sub>3</sub> (0.50, 0.50, 0.50) were found growing better.

1024. MANIKANDAN, P.; JOSHI, O.P.; KHAN, H. HAMEED. and BIDDAPPA, C.C. 1986. Available micronutrient status of the coconut tract of Kasaragod district, Kerala. *J. Plantn Crops* 14(2): 134-138. (CPCRI, Kasaragod, Kerala).

Soils under coconut in a strongly leaching climate are likely to be deficient in micronutrients if superphosphate application is discontinued as the fertilizer is a good carrier of micronutrients. Soil and leaf analysis data showed that there is prevalence of Cu, Zn and Mn deficiency in coconut growing soils in Kasaragod district, the coastal sandy soils being more deficient than laterite soils.

Soil analysis can, however, over estimate deficiencies as coconut can mine nutrients from horizons not sampled and also take up forms of the micronutrients not available to the extractants used. The lower percentage of

deficiency indicated by leaf analysis can be attributed to critical level of nutrients not being experimentally established and also to palms growing under nutrient stress conditions showing higher nutrient content due to a concentration effect.

1025. MATHAI, G. 1979. Effect of carbide ash as a liming material on the yield of nuts in coconut palm. *Agric. Res. J. Kerala* 17(1): 143-149. (RCRS, KAU, Kumarakom, Kottayam, Kerala).

In a fertilizer trial with 35-40 year old coconut palms, carbide ash which contains a percentage of 58-64 calcium, was applied. Similar quantity of dolomite also applied and compared the yield. But it was found that the average 8 year yield was lower than the unfertilized controls.

1026. MATHAI, G.; NAIR, K.P.V. and THAMPI, A.P. 1978. Fractional application of fertilizers for coconut seedlings. *Agric. Res. J. Kerala* 16(2): 160-165. (RARS, KAU, Kumarakam, Kottayam, Kerala).

Results of soil and foliar application of fertilizers on coconut seedlings are reported. Significant increase in the mean number of leaves produced were obtained due to fractionated application of NPK. Soil application of fertilizers was found better than foliar treatments. Early flowering, maximum number of spadices, large no. of female flowers and higher setting percentage were observed when the fertilizers were applied in split doses.

1027. MATHEW, CHACKO. 1977. The importance of magnesium in coconut nutrition. *Indian Cocon. J.* 8(8): 3-4. (CPCRI (RS), Kayangulam, Kerala).

The importance of magnesium in coconut nutrition has been fully realised. Experiments have been carried out in different parts of the world to study the role of mag-

nesium in the growth and yield of coconut palm. It has been observed that imbalance in the potassium magnesium ratio results in yellowing of leaves and reduction in yield.

**1028. MATHEW, CHACKO.** 1982. Aids to diagnose nutrient deficiency symptoms in coconut. *Indian Cocon. J.* 13(1): 3-5. (CPCRI, (RS), Kayangulam, Kerala).

Since the coconut palm continues to bear annually and lasts throughout its life from the time of flowering there is a steady utilization of nutrients from the soil and hence there is a continuous loss of the same from the soil. Unless this loss of nutrients is supplemented the palm would show certain deficiency symptoms. The article outlines methods by which such nutrient deficiencies could be diagnosed. Leaf analysis has proved to be a more reliable method than soil analysis. Deficiency due to lack of N, P, K, Ca, Mg, S and B are discussed.

**1029. MATHEW, S.; JOSE, A.I.; NARAYANAN NAMBIAR, P.K. and KANNAN, K.** 1984. Sodium chloride nutrition of coconut palms. *Agric. Res. J. Kerala* 22(1): 17-21. (College of Horticulture, KAU, Trichur, Kerala).

In trials with 24 year old hybrid palms, growing on laterite soil and receiving NPK fertilization, K applied conventionally as KCl at 1000 g K<sub>2</sub>O/palm annually was replaced by Na<sub>2</sub>O applied as NaCl for 5 years. The treatment did not reduce nut yield and did not alter pH, electrical conductivity and aggregate stability of the soil.

**1030. MURTHY, R.S.; BARDE, N.K.; NAGABHUSHANAM, S.R.; VENUGOPAL, K.R.; SHIVAPRASAD, C.R. and HARINDRANATH, C.S.** 1976. Soils of coconut garden areas in Maidan parts of Karnataka State, India. In: Coconut research and development; proceedings of international symposium, 1st CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayer. New

Delhi: Wiley Eastern. p. 11. (National Bureau of Soil Survey and Land Use Planning. (RC), Bangalore, Karnataka).

A study of coconut garden soils in Maidan region of Karnataka (parts of Hassan, Tumkur and Bangalore districts) was carried out. The soils are deep to very deep alluvial and colluvial in origin, light yellowish brown, reddish-brown to dark grey brown, coarse loamy to fine loamy, occasionally fine to very fine in some horizons, well-drained to moderately well-drained, rapid to slowly permeable, noncalcareous or calcareous, families of Inceptisols and Entisols. Studies of eleven representative soil series reveal a range of pH between 5.5 to 9.5, low to medium and high moisture retentivity, low to high available potash and potash-fixing capacity, presence of felsic minerals and lighter fractions of Bangalore district soils and ferromagnesium suited in the fractions of sand in Hassan and Tumkur district soils, where they are 'made up' by addition of extraneous materials as part of management practice. A map showing the distribution of coconut growing areas has been prepared.

**1031. NAGARAJAN, M.** 1985. Influence of saline environment on the incidence of stem bleeding in coconut (*Cocos nucifera* L.). *Sci. Cult.* 51: 349-351. (CPCRI, Kasaragod, Kerala).

The paper reports a case study on location specific saline-prone environment in a coconut grove with a large number of palms affected by stem bleeding disease. The results suggest the role of excessive salinity in stem bleeding incidence.

**1032. NAGARAJAN, M.; RETHINAM, P. and BIDDAPPA, C.C.** 1988. Radial dispersion of micronutrients through cement dust in coconut ecosystem. *J. Plantn Crops* 16(1): 52-54. (CPCRI, Kasaragod, Kerala).

Micronutrient (Fe, Mn, Cu and Zn)

emission through cement dust from 2 cement factories in Tumkur district of Karnataka was studied. Data are tabulated on the content of the 4 elements in cement manufacturing raw materials, micronutrient contents in the soil around cement factories (from 100 m to 5 km), and on micronutrient contents in coconut tissue at distances from 200 m to 5 km from the source of emission. Leaf Fe and Mn contents decreased with increasing distance from the factories, Cu content increased from 2.6 ppm at 200 m to 6.4 ppm at 5 km whereas the Zn content did not show significant variation.

**1033. NAIR, P.K.R. and WAHID, P.A. 1976.** The soil fertility factors associated with vigorous growth of young coconut palms. *Indian J. Agron.* 21(2): 150-153. (CPCRI, Kasaragod, Kerala).

Half of a group of 432 palms was fertilized with N, P, K, (80, 50, 80 kg/ha) for two years. Soils were examined in the area of vigorous growth and result indicated that the localized zone of soil associated with vigorous growth extended 1.5 m around the palms and changes in soil fertility with depth were most marked, in the 20-50 and 50-75 cm zone. Fertilized plots had slightly higher available P and exchangeable K values than unfertilized plots. The cationic ratio of the soil indicated that the less vigorous palms suffered from a lack of divalent cations. Leaf analysis indicated low Ca and K and high Na content in the unfertilized plots.

**1034. NALLATHAMBI, G.; RAMANATHAN, T. and MANOMOHAN LAL, S. 1988.** Effect of various organic manures on the yield of East Coast Tall coconut. *Indian Cocon. J.* 19(2): 3-8. (RARS TNAU, Veppankulam, T.N.)

An experiment was conducted on equal nutrients (2.10:0.55:2.60 kg NPK/palm) of various organic manures with required quantity of chemical fertilizers on East Coast Tall cultivar

from 1981 to 1985 at the Coconut Research Station, Veppankulam. The results revealed that farmyard manure with chemical fertilizers was found to be superior to the remaining treatments and control except green manure treated palms for increasing the nut yield of coconut. Farmyard manure and green manure treatments were equally effective and statistically on par with each other. The treatment with 100 kg farmyard manure + 2.4 kg urea + 1.4 kg muriate of potash per palm gave highest mean nut yield/palm/year (84 nuts) followed by the treatment with 100 kg green manure (74 nuts) as against 55 nuts per palm in the control. The per cent increases in nut yield were 53 and 34 in farmyard manure and green manure treatments respectively over control. The fruit components of coconut were not influenced by any of the treatments, the maximum copra (120 g/nut) with an increase of 18% over control was recorded only in farmyard manure treated palms.

**1035. NAMBIAR, C.K.B. and JOSHI, O.P. 1984.** Apply organic manure to reduce coconut mortality on coastal sands. *Indian Fmg* 34(5): 21-22. (CPCRI, Kasaragod, Kerala).

One-year-old West Coast Tall seedlings, planted 1m<sup>3</sup> pits, were fertilized annually with NPK alone or NPK supplemented with coir dust, coconut sheddings, leaves or FYM, each at 10 kg/plant, during the first 3 years and thereafter at double that rate N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O rates in the 1st and 2nd year were one third and two thirds, respectively, of 0.5:0.32:1.2 kg/plant/year applied during the 3rd and subsequent years. The 50% plant mortality under NPK alone was reduced to 15% under NPK + leaves or coir dust, and to 7% under NPK + FYM or coconut sheddings. Data are also tabulated on flowering.

**1036. NAMBIAR, C.K.B.; KHAN, H. HAMEED; JOSHI, O.P. and PILLAI, N.G. 1983.** A rational approach to the management of coastal sands

for establishment and production of coconut. *J. Plantn Crops* 11(1): 24-32. (CPCRI, Kasaragod, Kerala).

In a 10 year trial, 1-year-old coconut seedlings (cv. West Coast Tall) were planted in 1m<sup>3</sup> pits supplied with coir dust, coconut sheddings, leaf litter or cattle manure (analyses given), each at 10 kg/palm/year for the first 2 years and subsequently at 20 kg/palm annually, supplemented with N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O at 0.5, 0.32 and 1.2 kg/palm, respectively, each year. Palm height and leaf production were enhanced in all organic treatments, compared with control palms receiving NPK alone; leaf litter and cattle manure giving the best results. Palm establishment was also markedly improved and flowering advanced by several years, by all organic treatments. Data are also presented on the effects on soil characteristics, available nutrient content, and leaf nutrient element composition.

1037. NAMBIAR, C.K.B.; WAHID, P.A. and PILLAI, N.G. 1978. Effect of different organic sources on the performance of coconut seedlings in coastal sand. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM-I. Edited by E.V. Nelliath and others. p.292-301. (CPCRI, Kasaragod, Kerala).*

Response of coconut seedlings during the prebearing stage (5 years) to inorganic fertilizers and addition of organic matter in coastal sand was investigated at the Central Plantation Crops Research Institute, Kasaragod. Addition of organic matter, especially farmyard manure showed spectacular improvement of the vigour of the seedlings and enhanced their early establishment in the sand. Despite the porous nature of sand, fertilizer application helped to retain P and K. Organic matter content of sand was increased following continuous annual applications of organic manures for five years.

1038. PANDURANGAIAH, K. 1978. Effect of manuring on coconut palm and diagnostic study on deterioration in some coconut gardens. *Thesis Abstracts* 4:327-328. (Agricultural College, UAS, Bangalore, Karnataka).

A seven year study of the effects of spacing manuring in healthy and deteriorating coconut plantations is described. Continuous manuring lowered the pH and CEC of red but not black soils. Manuring red soils increased leaf N, P, K, Ca, Mg, Fe and Mn but not leaf Zn. Red soils in unhealthy plantations were poorer in P, K, Ca, Mg and Zn than healthy red soils, and unhealthy black soils were poor in Ca, Mg, P, Zn, Mn and organic matter. There were wide differences between healthy and unhealthy palms in their leaf P, K, Ca, Fe, Zn and Mn contents. The practice of growing swamp rice near the plantations adversely affected the soil physical properties by raising the water table.

1039. PANDURANGAIAH, K.; BADIGER, M.K. and DESHPANDE, P.B. 1978. Some aspects of diagnostic study on the deterioration in yield in some coconut gardens of Karnataka. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p.164-172. (UAS, Bangalore, Karnataka).*

The deterioration in the yield of coconut gardens is alarming in some parts of Karnataka. The study revealed that the coconut gardens on red soils showed wide variations under different conditions. The red soils of unhealthy gardens were low in P, K, Ca, Mg and Zn compared to those of healthy ones; while the black soils of sick gardens were low in organic carbon, Ca, Mg, P, Zn and Mn. Marked variations in the composition of leaf tissues under different conditions were indicative of disorders, as revealed by the wide nutrient ratios viz. N/P, K/Na, P/Mn and P/Zn. In addition, the

practice of raising wetland rice in the close vicinity of some of these gardens adversely affected the physical conditions of soil by rise in water table.

1040. POTTU, N.N. 1978. Studies on the variation in response of T x D coconut palms of different yield groups to fertilization. *Indian Cocon.J.* 8(12): 4-5. (Coconut Res. Station, KAU, Nilleshwar, Kerala).

Data are presented from a 5-year trial on the response of coconut palms with average pre-treatment yields of 80 or more, 60-80, 45-60 and 45 or fewer nuts/palm/year to N at 0-0.70 kg/palm,  $P_2O_5$  at 0-0.35 kg/palm and  $K_2O$  at 0-1.40 kg/palm. In the highest yielding group there was a marked response to P at the highest level and N and K at intermediate levels. In the lowest yielding group there was little response to P, but a marked response to K at the highest level.

1041. PRABHAKARAN, P.V.; BALACHANDRAN NAIR, G.K.; PADMANABHAN THAMPI, A.; SIVASANKARA PILLAI, K.; RAMACHANDRAN NAIR, V.; MADHAVAN NAIR, G.; PUSHPANGADAN, K.; SUKUMARAN, K.M.; RAGHAVAN PILLAI, G. and KOSHY, E.P. 1988. Fertilizer requirement of WCT coconut palms in red loam soils; an alternate approach based on the principle of game theory. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur. Nov. 23-26, 1988. Abstracts of papers. p.41. (Coconut Res. Station, KAU, Balaramapuram, Trivandrum, Kerala).

The principle of game theory was used for the interpretation of data of a long term fertilizer trial on WCT coconut in red loam soils at Balaramapuram and specific recommendations for farmers with varying decision environments were made. The various decision criteria such as, Wald's Maximin, Laplace, Harvitz., the minimum regret and the excess

benefit were used on the pay off matrix in the form of output and net return per tree and the optimum strategies under risk were arrived at. The results of analysis showed that application of NPK at the rates of 680 g of N/palm, 450 g of  $P_2O_5$ /palm and 900 g of  $K_2O$ /palm was the best treatment for the range of nutrients covered in the experiment. The choice of such a strategy (treatment) not only assures maximum yield and net returns to the farmer but also affords maximum security under risky environments.

1042. PREMA, D.; JOSE, A.I. and NARAYANAN NAMBIAR, P.K. 1987. Effect of sodium chloride on growth and yield of coconut palms in a laterite soil. *Agric. Res. J. Kerala* 25(1): 66-73. (College of Horticulture, KAU, Trichur 680 654, Kerala).

An investigation was carried out drawing soil and leaf samples from coconut palms of a sodium chloride trial conducted at the Regional Agricultural Research Station Pilicode, Kerala, in order to evaluate the effect of sodium chloride on growth, yield and uptake of nutrients by coconut palms grown in laterite soil. The treatments were superimposed on 24 year old palms in 1976 and samples for the study were drawn in 1986. The palms were receiving substitution of KCl by NaCl in various proportions for the last 10 years. The study revealed that there was no significant difference in yield of nuts by substitution of KCl by NaCl. However, treatments receiving 100% recommended dose of  $K_2O$  and that receiving 50% substitution of  $K_2O$  by  $Na_2O$  appeared superior to other treatments. There was no significant difference between treatments in the case of other palms receiving higher amount of K or Na. The available nutrient status of the soil except available K and basic chemical properties of soil like pH, EC and CEC remained the same. The available K content in soil increased with increased application of K to the soil.

1043. RAMANANDAN, P.L. and GEORGE, M.V. 1984. Interaction of soil groups on the nutrient exhaust by coconut. *In: Symposium on Plantation Crops, 5th, CPCRI, Kasaragod, Dec. 15-18, 1982. Proceedings of PLACROSYM V. Edited by K.V.A. Bavappa and others. p.482-490. (CPCRI, Kasaragod, Kerala).*

Results of investigation carried out to study the effect of soil groups on the nutrient content of various components of coconut fruit are reported in this paper. Potash was found to be removed most, followed by nitrogen, calcium, magnesium and phosphorus. Soil types were found to influence the nutrient exhaust by nuts. On comparison, palms growing on coastal alluvium removed 70 kg  $K_2O$  ha<sup>-1</sup> whereas the average value for red sandy loam and laterite was 53 Kg  $K_2O$  ha<sup>-1</sup>.

1044. RAMANANDAN, P.L. and MULIYAR, M.K. 1978. Long term effects of cultivation and manuring on coconut soil. *In: Symposium on Plantation Crops, 1st, RRIL, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p.303. (CPCRI, Kasaragod, Kerala).*

Under the climatic and soil conditions existing at the Central Plantation Crops Research Institute, Kasaragod, regular cultivation and manuring are necessary to increase and maintain the yield at a high level in coconut. Regular cultivation by itself is effective in increasing yields, even in the absence of manuring. Soil samples collected during six consecutive years were analysed for N,  $P_2O_5$ ,  $K_2O$ , CaO and MgO. Cultivation alone as well as cultivation and manuring increased the available  $P_2O_5$  and  $K_2O$  in the soil in comparison with the uncultivated and unmanured plot.

1045. RAY, P.K. 1979. Radio isotopes studies on coconut nutrition. *In: International Symposium, Austria (Vienna), IAEA-SM-235/54.*

Proceedings. p.573-580. (JARI, Barrackpore, W.B).

Studies on coconut nutrition using radio isotopes are reviewed. Methods of soil placement and plant injection techniques for efficient uptake and utilization of nutrients are suggested. The absorption, distribution and translocation pattern of radio active phosphorus and its incorporation into the nucleic acid fraction in healthy and root(wilt) diseased coconut palms have been studied. Carbon assimilation rates (using carbon-14) in spherical, semispherical and erect canopied coconut palms having different yield characteristics are reviewed and discussed.

1046. RAY, P.K.; DWIVEDI, R.S. and NINAN, SUNNY. 1978. Efficiency of different methods of fertilizer application in coconut using radio-isotope technique. *In: Symposium on Plantation Crops, 1st, RRIL, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYM I. Edited by E.V. Nelliath and others. p.331-339. (CPCRI (RS), Kayangulam, Kerala.)*

Different methods of plant injection and soil placement techniques were tried.  $KH_2^{32}PO_4$  was used in this study which was simultaneously confirmed by tagged single superphosphate fertilizer application. In plant injection technique,  $^{32}P$  was fed to the palms through growing root tip, cut end of root, stem injection and leaf axil application; whereas in soil placement method, the radio-active P was applied to the palms through basin, circular trenches, stripes and holes made around the bole. Plant injection technique was efficient and economical than soil application method. Among plant injection methods, the application of  $^{32}P$  through cut-end of roots was efficient and the radio activity in the palm was detected after 4 hours of application. On the other hand, the radio activity in the palm was detected after 8, 12 and 18 hours of application through stem, leaf axil and growing root tip, respec-

tively. Out of four methods of soil application tried, the placement of radio active P through holes gave quick recovery.

1047. REMANY, C. 1983. Essential elements in coconut nutrition and their deficiency symptoms. *Indian Cocon. J.* 14(7): 8-11. (Coconut Development Board, Cochin, Kerala).

The important functions and deficiency symptoms of N, P, K, Ca, Mg, S and Cl as well as micronutrients such as Manganese, Copper, Zinc, Boron, Molybdenum are briefed in the article. Timely diagnosis and correction of mineral deficiencies can play a very important role in the successful management of the palm.

1048. SAJEEV, V. 1990. Nutrient - yield inter relationships in coconut and coconut growing soils. M.Phil. dissertation. Mangalore University, Mangalore. p.95. (CPCRI, Kasaragod, Kerala).

The study leads to the following conclusions:

1. The soil available N content did not show significant variation with increased level of N fertilization continuously for a number of years suggesting that N cannot be built up in the soil. This may be due to various losses of N that are taking place in the soil.
2. The increased supply of N, P, K increase the leaf N, P, K status in the index leaf of coconut, because of higher availability of these nutrients at higher level of fertilizer application.
3. The yield of coconut significantly increased with increased level of fertilization through increased uptake.
4. Irrigation generally increased the available nutrient level in the soil, due to mineralisation.
5. T x D depletes the soil nutrients much faster than that of D x T and WCT, while WCT depletes lesser nutrients than the hybrids as evidenced from soil nutrient status.
6. Heavy application of P and K through fertilizers generally favours the higher build up of these nutrients in the soil.

1049. REDDY, L. SHIVARAMA. 1989. Chlorosis or yellowing of leaves, a sign of unproductivity in coconut. *Indian Cocon. J.* 20(4): 9-10 (Coconut Development Board, Regional Office, Bangalore, Karnataka).

Chlorosis or yellowing of leaves in coconut palms as attributed to adverse soil moisture, higher temperature and nutrient imbalance were discussed. The symptoms of yellowing of leaves due to adverse soil and climatic conditions are noticed in all the stages of plant growth, but the intensity varied with the acuteness of above factors. The incidence of chlorosis can be avoided or minimised through systematic management practices.

1050. SINGH, G. and GANESHAMURTHY, A.N. 1987. Effect of salinity on the growth of coconut seedlings. *J. And. Sci. Assn.* 3(2): 148-149. (CARI, Port Blair, A & N Islands).

In greenhouse experiments, seedlings of the cultivars Katchal Tall and Katchal Dwarf were raised in sand beds. Plastic pots were filled with 16 kg salt-free sand and treated with sea water to obtain salinity equivalent to EC level of 2.5, 5, 10, 20 and 40 ds/m. The seedlings were then planted in these pots and grown for 4 months. Katchal Tall survived at all salinity levels whereas Katchal Dwarf showed 25 and 100% mortality at 20 and 40 ds/m salinity levels, respectively.

1051. SINGH, K.D. and VELAYUTHAM, M. 1980. Nutrient indexing in coconut leaves and soils of Lakshadweep Islands, II: micronutrient aspects. *Indian Cocon. J.* 10(9): 1-3. (ICAR Research Complex for Goa (CPCRI), Margao, Goa).

Data are presented on the range of leaf and soil Mn, Fe, Zn and Cu contents found in 10 localities. Leaf Mn levels varied from 12 to 35 ppm (the critical level being 66 ppm), reflecting marked soil deficiency of this element. Leaf Fe levels varied widely between deficient (67 ppm) and excessive (317 ppm).

Leaf Zn levels ranged between 10 and 72 ppm (the optimum being 11 ppm) and Cu levels from 5-11 ppm (optimum 12.5 ppm). Cultural methods of maintaining and enhancing soil fertility are listed.

**1052. SINGH, SHYAM and VIRENDRA KUMAR.** 1989. Effect of NPK doses on coconut cultivar, Andaman Tall. *J. And. Sci. Assoc.* 5(1): 43-48. (CARI, Port Blair, A & N Islands).

An experiment with three doses each on N (0.5, 1.0 and 1.5 kg), P (0.25, 0.50 and 0.75 kg) and K (0.75, 1.25 and 1.75 kg) per palm/year on coconut local cultivar Andaman Tall (Ordinary) was conducted during 1973-87 on hill slopy condition at the Central Agricultural Research Institute, Port Blair, South Andaman. The results revealed a negligible effect of N and P but K had positive beneficial role in nut production upto a dose of 1.25 kg/palm/year. The kernel weight and thickness remained unaffected by fertilizer treatments.

**1053. SOMASHEKAR, R.K.** 1984. Trace metal status of coconut plants of a polluted area in Mysore (India). *In: Proc. natn. Acad. Sci. Pt. B.* 50(5): 535-538. (Dept. of Botany, Bangalore University, Bangalore, Karnataka).

Differential accumulation of heavy metals among coconut palms growing in the polluted area was investigated. The accumulated concentration of metals such as Ni and Cu in coconut root and leaf extract was 46.84 and 10.89 mg, 32.32 and 19.70 mg respectively. Coconut water contained 12.6 mg of Ni, 15.45 of Cr and 14.13 mg<sup>-1</sup> of Cu.

**1054. SUMATHYKUTTY AMMA, B.** 1977. Soil organic matter, the need for its enrichment. *Indian Cocon. J.* 8(6): 1. (CPCRI (RS), Kayangulam, Kerala).

Maintenance of organic matter in the soil is vitally important and calls for careful husbandary especially in coconut growing tropics where it is oxidised rapidly and ex-

hausted. Importance of organic matter content of the soil is therefore discussed.

**1055. SUMATHYKUTTY AMMA, B.** 1982. Soil aeration : a must for coconut root growth. *Indian Cocon. J.* 12(10): 9-10. (CPCRI (RS), Kayangulam, Kerala).

Importance of soil aeration for the existence of a healthy root system is highlighted. Low aeration (low oxygen content) leads to low absorption of water and minerals, retards root growth and causes soil toxicity. Factors affecting soil aeration and methods of increasing soil aeration are also mentioned.

**1056. VALIA, R.Z. and PATIL, V.K.** 1990. Effect of soil salinity on physiological parameters and chemical composition of coconut. *In: Symposium on Plantation Crops, 9th, CCRI, Chickmagalur, 5-6 Dec., 1990.* Abstracts of papers. p.70. (Dept. of Horticulture, B.A. College of Agriculture, GAU, Anand, Gujarat).

Seedlings of coconut (*Cocos nucifera* L.) in naturally saline soil and artificially salinized soils of conductivity ranging from 4 to 20 mmhos/cm were maintained for 12 months under pot culture. As salinity increased the leaf chlorophyll 'a', 'b' and total chlorophyll content and the rate of transpiration decreased, the number of stomata however was increased. With the increased salinity nutrients like N, P, K, Ca, Mg, Na, Zn, Mn and Cu were depleted in leaves and roots. Sulphur content increased in leaves and roots with the increase in salinity upto 8 mmhos/cm. However, beyond this salinity level sulphur content was found to be decreased. Sodium content of all plant parts increased with the increase in salinity levels, however, the maximum increase was recorded in root. With the increase in salinity the ratio of Ca:Na and Ca+Mg+K:Na was those ratios in roots as was observed at the initial level of salinity as compared to control.

**1057. VIJAYARAGHAVAN, H.; MANMOHAN**

LAL, S. and RAMANATHAN, T. 1988. Effect of zinc on yield of coconut. *Indian Cocon. J.* 18(11): 3-8. (Coconut Res. Station, Veppankulam, T.N.).

A field experiment was conducted to study the effect of zinc and copper on the yield of coconut at the Coconut Research Station, Veppankulam in a block where this particular micronutrient was found deficient. Soil application of 200g zinc sulphate per palm per year along with recommended doses of NPK for a period of five years proved to be effective in ameliorating zinc deficiency besides increasing the nut yield by 69.5% over control. A net income of Rs. 7000 in one acre of coconut plantation could be realised by the application of 200 g zinc sulphate with the cost - benefit ratio of 1:31.5.

1058. VIJAYARAGHAVAN, H.; RAVEENDRAN, T.S. and RAMANATHAN, T. 1988. Effect of zinc nutrition on a zinc deficient soil. *J. Plantn Crops* 16(Suppl.): 31-33. (Coconut Res. Station, Veppankulam, T.N.).

An experiment conducted at the Coconut Research Station, Veppankulam, Tamil Nadu, representing East Coast belt indicated that application of 200 g  $ZnSO_4 \cdot 7H_2O$ /palm/year was effective in ameliorating zinc deficiency besides increasing the nut yield of coconut palms to the extent of 49.7%. Nut characters were not altered by the treatment.

1059. WAHID, P.A. 1984. Diagnosis and correction of nutrient deficiencies in coconut palm. *J. Plantn Crops* 12(2): 98-111. (Radiotracer Laboratory, College of Horticulture, KAU, Trichur, Kerala).

Literature relevant to the nutrient requirement and diagnosis of nutrient deficiencies in coconut palm is reviewed. It is suggested that the interpretation of effects of fertilizer application on the growth and coconut production will be more meaningful in terms

of the quantity and type of fertilizers used rather than in terms of a specific nutrient contained in them.

The essential mineral nutrient elements in coconut are distinguished into two groups based on the yield responses to applied fertilizers and the nature of relationship between foliar nutrient levels and yield of nuts and/or copra. Group-I nutrient elements which are directly involved in coconut production include N, K and Cl while Group-II nutrients that effect the yield only when their levels in the palm are too low for the satisfactory growth, comprise P, Ca, Mg, S and probably the micronutrients as well. The applicability of critical nutrient level concept is discussed in respect of these two groups of nutrients. It is pointed out that 'chemical diagnosis' and correction of deficiencies based on foliar critical levels are effective only in the case of Group-I nutrients while 'visual diagnosis' is the most practical approach in the detection of deficiencies of Group-II nutrients. Routine leaf analysis for the diagnosis of latent deficiencies of N, K and Cl and correction of their deficiencies based on foliar critical levels is recommended for sustained yields in coconut gardens. Regular monitoring of foliar levels of Group-II nutrients is not recommended. The leaf analysis in this case, will be helpful only to confirm the visible deficiency symptoms of the suspected nutrient.

1060. WAHID, P.A.; KAMALADEVI, C.B. and HARIDASAN, M. 1977. Critical review of phosphate fertilization of coconut. *Philipp. J. Cocon. Studies* 2(4): 1-8. (CPCRI, Kasaragod, Kerala).

A review and discussion, with tabulated data on nutrients removed annually by the coconut palm; analysis of various parts of a productive coconut palm; P x K interaction on copra yield; P concentration gradient in coconut basins receiving annual applications of P for 15 years; yield of nuts/palm from treat-

ments with and without P; mean soil and leaf P content of healthy palms; P percentage in leaves of tall; semi-tall and dwarf palms; and leaf P status in relation to fertilization.

1061. WAHID, P.A.; KANNAN, K.; KAMALAM, N.V. and VENUGOPAL, V.K. 1981. Genotypic and seasonal variations in the mineral nutrition of coconut palm. *J. Plantn Crops* 9(2): 105-111. (KAU, Trichur, Kerala).

Data are tabulated on the yield, soil chemical characteristics in the basins, and nutrient concentrations (N, P, K, Na, Ca, Mg, S, Cu, Fe and Mn) in the leaves of 10 coconut cvs. and hybrids receiving uniform NPK fertilization. The pattern of variation in nutrient levels did not differ markedly in the different cvs. and hybrids. Generally leaf N declined with the onset of the monsoon and increased following fertilizer application in September. Leaf K level increased until December and decreased thereafter, whereas Ca and Mg increased after December. Leaf P increased slightly and S and Fe decreased during the rainy season. The Cu and Mn levels were little affected by the seasons. Na fell to its lowest level in September and increased thereafter. The best time for foliar diagnosis under Kerala conditions was December.

1062. WAHID, P.A. and NAMBIAR, C.K.B. 1978.

Nutrient uptake index for evaluating nutrient removal by coconut palm (*Cocos nucifera* L.) during pre-bearing stage. *In: Symposium on Plantation Crops, 1st, RRII, Kottayam, Mar. 20-23, 1978. Proceedings of PLACROSYMI. Edited by E.V. Nelliath and others. p.173. (CPCRI, Kasaragod, Kerala).*

An index method that permits comparison of removal of a nutrient by coconut palm at any given stage of growth before bearing, is described in this paper. Nutrient uptake index (NUI) for a given nutrient is arrived at by multiplying the nutrient concentration (per cent) in composited leaf sample by the number of leaves present at the time of sampling. NUI is expressed as a mere number and is taken as an estimate of the absolute quantity of the nutrient removed by the palm. The scope of the method is discussed.

1063. WAHID, P.A.; NARAYANAN NAMBIAR, P.K.; JOSE, A.I. and RAJARAM, K.P. 1988. Soils and nutrition. *In: Six decades of coconut research. Mannuthy: Kerala Agricultural University. Edited by M. Aravindakshan and others. p.46-80. (RARS, KAU, Pilicode, Kerala).*

Soil, fertilizer requirements and nutritional aspects taken up in the Kerala Agricultural University were summarised in this Chapter.

## 13. POST HARVEST TECHNOLOGY

### 13.1 Building Material

1064. ACHYUTHAN, A. and JAYADEVAN. 1987. Project profile for coconut wood panelled doors. *Indian Cocon. J.* 18(4): 11-15. (State Committee on S & T and Environment, Calicut, Kerala).

The coconut wood can be used as narrow panels of 10-15 cm width and 3 to 4 cm thickness after seasoning it by drying in air. This will have a lot of market demand as good quality panelled doors. The project profile for coconut wood panelled doors is explained. As about 37,500 old trees are cut every year in the Calicut district alone, there will not be scarcity of raw materials for this project. The machineries required and cost analysis are also explained.

1065. DEVADAS, C.T.; PALANISWAMY, P.T. and SWAMINATHAN, K.R. 1988. Process development of making briquettes from coir pith wastes for fuel purpose. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov.23-26, 1988. Abstracts of papers. p.52. (College of Agric. Engineering, TNAU, Coimbatore 641 003, T.N.).*

The conversion of coir pith into fuel briquettes with cowdung as a binding material (6:1) is attempted. For this, a continuous horizontal extrusion type briquetting machine consisting mainly of an overhanging screw shaft, a barrel housing and an extruder die-pipe (65 cm dia) was developed in TNAU, Coimbatore. The screw shaft is coupled directly to a reduction gear unit (10:1) and is driven by a 5 HP electric motor. The length of the hollow briquettes produced vary from 5 cm to 10 cm with a calorific value of 3000 K cal/kg. The capacity of the machine is 125 kg/h and the approximate cost of the machine is Rs. 10,000/-.

1066. GEORGE, JOSEPH. 1983. Building material from coconut husk and its by-products. *In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.284-289. (Indian Plywoods Industries Res. Institute, Bangalore 560 022, Karnataka).*

Possibilities of utilizing coconut husk in preparing quality particle boards and layered particle boards with coconut husk particle and wood particle faces are extensively reviewed. By-products of coir industry such as retted pith, baby fibre, and shearing waste therefore bonded with portland cement can be made into slabs of high thermal insulation value.

1067. GNANAHARAN, R. and DHAMODARAN, T.K. 1989. Effect of wilt disease and age on the strength properties of coconut palm stem wood. *Wood Sci. Technol.* 23. 205-209 (KFRI, Peechi, Kerala).

Static bending test and compression test parallel to the grain were conducted on coconut stem wood from non-diseased over-mature palms and wilt-diseased palms of different age groups; properties like fibre strength at limit of proportionality (FSLP) modulus of rupture (MOR), modulus of elasticity (MOE), work to maximum load (WML) and maximum crushing strength (MCS) were determined and are comparable with other structural timbers. Wilt disease did not have any adverse effect on strength properties, but over-mature palms had significantly higher MOE values than lower age palms.

1068. GNANAHARAN, R. and DHAMODARAN, T.K. 1989. Preservative treatment of stem wood of wilt-diseased coconut palms. *J. Trop. Sci.*

1(4): 341-345. (KFRI, Peechi 680 653, Kerala).

Sawn wood from wilt-diseased coconut palms were treated with copper-chrome-arsenate preservative under pressure and boron chemicals under diffusion process. There is strong negative relationship between density of wood and dry salt retention (DSR) of preservative chemicals. Thus, preservative solution strength can be varied, if necessary, to get the required retention of chemicals. Stem wood of wilt-diseased coconut palms can be treated to adequate retention of chemicals and depending on end-use; the type of preservative and treatment can be chosen.

1069. GNANAHARAN, R.; DHAMODARAN, T.K. and THULSIDAS, P.K. 1985. Sawn timber output from wilt-diseased and non-diseased coconut palms. *Indian Cocon J.* 16(21): 6-12. (KFRI, Peechi 680 653, Kerala).

The sawn timber output of non-diseased senile coconut palms and that of root (wilt) diseased palms of different age classes was quantified. Recovery of sawn sizes is higher from non-diseased senile palms (26.5%). The diseased palms of lower age groups (15 to 45 years) contain only 12 to 16% sawn sizes and the remaining portion is of low density and high moisture content. Linear regression equations on the relationship between height and sawn timber output have been arrived at separately for non-diseased senile palms and wilt-diseased palms of all age groups.

1070. GNANAHARAN, R.; DHAMODARAN, T.K. and THULSIDAS, P.K. 1986. Physical properties of stem wood of wilt diseased and non-diseased coconut palms. *Indian Cocon. J.* 16(10): 1045. (RRL, Trivandrum, Kerala).

Stem wood density and volumetric shrinkage of non-diseased senile palms and wilt-diseased palms of different age groups have been reported. Stem wood density increases with age but did not differ signifi-

cantly from basal and middle portions. However, there was no significant difference in volumetric shrinkage among the groups, and between the basal and middle positions of the tree. Fibre saturation point and green to oven-dry volumetric shrinkage of coconut palms are 23.3% and 9.6% respectively.

1071. GNANAHARAN, R.; DHAMODARAN, T.K. and THULSIDAS, P.K. 1988. Yield and quality of charcoal from coconut stem wood. *Biomass* 16: 251-256. (KFRI, Peechi, Kerala).

A portable type 'Tongan kiln' was used to produce charcoal from stem wood of over-mature coconut palms and wilt-diseased palms of different age groups. The charcoal yield, ranged from 26 to 29%, the fixed carbon content in moisture-free charcoal varied from 67 to 76%, volatile matter content from 20 to 30% and ash content from 1 to 5%. The yield and quality of charcoal remained same irrespective of the age of the palms and diseased state.

1072. MATHAI, G. 1979. Coconut shell, a useful waste. *Sci. Rep.* 16(8): 362. (RARS, KAU, Kumarakom, Kottayam, Kerala).

Different commercial use of coconut shell is reviewed in this paper.

1073. NANDA KUMAR, T.B. 1989. Art for art's sake. *Indian Cocon. J.* 20(3): 25-26. (Coconut Development Board, Cochin, Kerala).

Success story of an artisan in Karnataka who makes handicraft items using coconut shells. His observation on the various characteristics of the shell are given.

1074. PILLAI, C.K.S. and ROHATGI, P.K. 1981. Mechanism of deterioration of thatch and its prevention. *J. Sci. Ind. Res.* 40(6): 363-372. (RRL, Trivandrum, Kerala).

Recent information on the deterioration of thatch from various plant sources is reviewed.

The relative merits and limitations of various methods employed for preservation of thatch are discussed.

1075. PILLAI, C.K.S.; VENKATASWAMY, M.A.; SATYANARAYANA, K.G. and ROHATGI, P.K. 1983. Preserving coconut leaf thatch; a simple method. *Indian Cocon. J.* 14(8): 3-6. (RRL, Trivandrum, Kerala).

Studies have been made to improve the life of coconut leaf thatch by using a combination of copper sulphate and cashewnut shell liquid. A simple process for imparting the treatment is described.

1076. PILLAI, C.K.S.; VENKATASWAMY, M.A.; SATYANARAYANA, K.G.; SREEDHARAN, V.P.; INDIRA, C. and ROHATGI, P.K. 1982. A mechanical study of the deterioration of coconut leaf thatch under natural and accelerated environmental conditions. *J. Mater. Sci.* 17: 2861-2868. (RRL, Trivandrum, Kerala).

The strength of coconut leaf thatch was found to decrease on its exposure to both natural and accelerated environmental conditions such as natural weathering, accelerated conditions of rain and alternate wet and dry climate and micro-organisms such as fungus. Scanning electron and stereo-optical microscopes were also used to study the fracture phenomena and surface changes during deterioration. The major factors contributing to the deterioration of coconut leaf thatch are rain, alternate wet and dry weather and decay by fungus.

1077. RAMASWAMY, K.; GOWDER, K.R. KARAI and SWAMINATHAN, K.R. 1988. Coir pith packed chulhas in fuel energy conservation. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.50-51. (College of Agric. Engineering, TNAU, Coimbatore 641 003, T.N.).*

Trials were conducted to use coir dust as a packing material in chulhas made up of mild steel sheets of having a top opening of 18.5 cm diameter for placement of cooking vessel and 6.5 cm diameter inlet opening at the front for inserting fuelwood and having central cylindrical welded mesh cage and 8 cm diameter. Results of the experiments on water heating and cooking rice by boiling method revealed that only one fourth of firewood is required as that of conventional single holed mud chulhas. Coir pith packed chulha possesses 47 per cent thermal efficiency. It is also estimated that there will be an energy saving of  $1.35 \times 10^{13}$  Kcal with a cost equivalent of Rs. 3,150 million per annum if all the coir dust available in India is effectively utilised.

1078. VIJAYALEKSHMI, B.; PRASAD, V.S.; PILLAI, C.K.S.; SATYANARAYANA, K.G. and ROHATGI, P.K. 1984. Fire retardant cum life extended coconut leaf thatch as roofing material. *In: International Conference on Housing, CBRI, Roorkee, 1984. Proceedings of seminar. p.151-155. (RRL, Trivandrum, Kerala).*

The process developed and the ensuing results to extend the life of coconut leaf thatch from one year to four years and to make it fire-retardant for short term uses are presented.

1079. SATYANARAYANA, K.G.; MOHANDAS, P.N.; PILLAI, C.K.S.; PAVITRAN, C.; GOPAKUMAR, K. and ROHATGI, P.K. 1984. Characterisation and utilization of coconut tree based materials. *Indian Cocon. J.* 14(9): 18-25. (RRL, Trivandrum, Kerala).

The potential utilization of a wide variety of coconut wastes have been reported including coir fibre, pith, shell powder, shell char etc. Causes for the decay of coconut leaf thatch and successful solutions to prevent the decay are described. Further utilization of coconut leaf as panelling materials is reported.

1080. SATYANARAYANA, K.G.; PILLAI, C.K.

SUKUMARAN, K.; PILLAI, S.G.K.; ROHATGI, R.K. and KALYANI VIJAYAN. 1982. Structure property studies of fibres from various parts of the coconut tree. *J. Mater. Sci.* 17: 2453-2462. (RRL, Trivandrum, Kerala).

Fibres from different structural parts of the coconut palm (*Cocos nucifera*, Linn.) have been examined for properties such as size, density, electrical resistivity, ultimate tensile strength, initial modulus and percentage elongation. The stress-strain diagrams, fracture mode, micro-fibrillar angle as well as cellulose and lignin contents of these fibres have been determined. Some potential uses of these fibres have been listed.

1081. SREEDHARAN, V.P.; PILLAI, C.K.S.; VENKATASWAMY, M.A. and ROHATGI, P.K. 1988. The role of micro-organisms in the decay of coconut leaf thatch. *Inter. Biodeterioration* 24: 75-79. (RRL, Trivandrum, Kerala).

Five fungi associated with the decay of coconut leaf thatch, a low cost organic roofing material used widely in Kerala (India), were isolated and identified as *Aspergillus niger*, *A. tamarii*, *Penicillium citrinum*, *Pestalotiopsis palmarum* and *Botryodiplodia theobromae*. The species actively involved in reducing the tensile strength of the leaf and thus shortening the life span of the leaf are *A. niger* and *P. citrinum*. The other three fungi are possibly involved only in causing surface damage to the leaf.

## 13.2 Coconut Oil

1082. BHAT, S.G. 1987. Coconut oil and its derivatives. *Indian Cocon. J.* 18(2 & 3): 22-25. (Res. and Development Laboratories, Tata Oil Mill Company Ltd., Bombay 400 033, Maharashtra).

The processes of extraction of coconut oil and its major uses (both industrial and edible) are summarised. The specification of coconut oil, fatty acid composition as well as the various applications of fatty acid derivatives are presented.

1083. GOPALAKRISHNAN, N.; ARUMUGHAN, C. and NARAYANAN, C.S. 1984. A method for the detection of palmolein in coconut oil. *J. Oil Technol. Ass. India* 15(3): 89-90. (RRL, Trivandrum, Kerala).

The method for the detection and estimation of adulteration in coconut oil with palmolein involves treatment of the oil with Carr-Price reagent. Presence and extent of admixture of palmolein is indicated by the intensity of a bluish black colour.

1084. GOSWAMI, ASHOK. K. 1983. Role of Sodium Dodecyl Sulphate in the stabilization of coconut oil/water emulsion. In: *Coconut research and development; proceedings of the international symposium, Kasaragod, Dec. 27-31, 1976*, edited by N.M. Nayar. New Delhi: Wiley Eastern. p.254-257. (Dept. of Chem., K.R. College, Mathura 281 001, U.P.).

The role of sodium dodecyl sulphate (SDS) in the stability of coconut oil in water emulsion has been studied. Flocculation studies were made haemo-cytometrically in the presence of varying concentrations of different electrolytes, viz., sodium, chromium, lead, and thorium. Zeta potentials were calculated from the mobility data obtained micro-electrophoretically in the presence of electrolytes. The high stability of

the coconut oil/water emulsion proves its paramount importance in cosmetic industry.

1085. LAKSHMINARAYANA, T.; AZEEMODDIN, G.; ATCHUTHA, RAMAYYA, D. and RAO, S.D.T. 1984. Direct bleaching of brown coconut oil. *Indian Cocon. J.* 15(6): 15-16. (Oil Technological Research Institute, Anantapur 515 001, A.P.).

Brown coconut oil, a product from inferior grade copra was bleached to light yellow colour by pre-treatment with hydrogen peroxide or oxalic acid followed by bleaching with earth and carbon.

1086. NAGARAJAN, M. and NAIR, R.B. 1981. A rapid turbidity procedure for estimation of oil content in copra, fresh coconut endosperm and allied tissue materials. *Sci. Cult.* 47: 151-154. (CPCRI, Kasaragod, Kerala).

The principle that turbidity of an emulsion formed by addition of water to fats or oils in a mixture of  $\text{CCl}_3\text{COOH}$  in  $(\text{CH}_3)_2\text{C}=\text{O}$  can be compared and measured quantitatively has been applied in the rapid procedure for estimation of fats or oils in different tissue materials of coconut in their dry and even fresh forms (utilizing even milligram quantities of materials). It appears to be a simple and reliable approach for routine work and capable of giving comparable results and also there seems to be an added advantage to skip-over whenever imperative certain time consuming preliminaries to process out fresh coconut endosperm to copra for oil estimation. Calibration graph based on linear equation derived to show that  $Y$  (oil concentration) =  $-0.3549 + 31.97 \times$  (extinction) ( $R^2$  value 96.5%), procedure (with precautions) and their application and precision of estimations are mentioned and discussed.

1087. NAIR, P.G.; VISHWANATHAN and

**GOPAKUMAR, K.** 1981. Effect of long term feeding of a coconut oil based diet and a combined coconut and fish diet on serum cholesterol and fatty acid composition of different organs of Albino rats. *J. Food. Sci. Technol.* 18(5): 187-191. (CIFT, Cochin, Kerala).

The influence of sardine oil (*Sardinella longiceps*) and coconut oil together on the fatty acid composition of various organs and on the serum cholesterol level of albino rats was studied. The level of arachidonic acid in the liver was found to be independent of the dietary supply of this acid, but appeared to be related to the level of linoleic acid in the diet. Dietary sardine was found to be very effective in lowering the serum cholesterol level even in the presence of cholesterol elevating agent such as coconut oil. This effect can be due to the high content of polyunsaturated acids in fish lipids as well as the nature of fish proteins.

**1088. NANDA KUMAR, T.B.** 1981. Coconut oil, the king of vegetable oils? *Indian Cocon. J.* 11(9): 5-9. (Coconut Development Board, Cochin, Kerala).

Information on the medicinal properties of coconut oil are compiled and presented. Role of coconut oil in the incidence of heart disease is also reviewed.

**1089. NANDAKUMAR, T.B.** 1982. Kerala solvent extractions limited; a notable industry in Kerala. *Indian Cocon. J.* 13(1): 13-16. (Coconut Development Board, Cochin, Kerala).

The method of solvent extraction of coconut cake to get the residual oil is described in detail. The dried cake is used as cattle feed and the oil, after refined is used for edible purposes.

**1090. NARAYANAN NAMBIAR, P.K. and RAO, G.S.L.H.V. PRASADA.** 1988. Varietal and seasonal variations in the oil content of coconut. *In: National Symposium on Coconut*

*Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.43. (RARS, KAU, Pilicode 670 353, Kerala).*

The monthly percentage oil content of five coconut cultivars viz., West Coast Tall (WCT), Laccadive Ordinary (LO), Gangabondam (GB), Chowghat Orange Dwarf (COD) and Laccadive Dwarf (LD) and their hybrids was studied. LO had the maximum (73.0 per cent) oil content, minimum by COD (66.0 per cent), while WCT recorded (70.8 per cent) oil content, by LD (68.4 per cent) and GB (67.3 per cent). The oil contents of the five hybrids were 70.4 per cent for LO x GB, 69.7 per cent for WCT x GB, 68.7 per cent for WCT x LO, 67.2 per cent for COD x WCT and 66.7 per cent for WCT x CDO.

The maximum (72.8 per cent) oil content was recorded during the post monsoon (October and November), followed by the winter (December to February) (71.3 per cent) and the minimum (66.6 per cent) during the summer (March to May).

**1091. NASIRULLAH, K.N. ANKALAH and NAGARAJA, K.V.** 1986. Oxidative rancidity in coconut oil with respect to storage variation. *J. Oil Technol. Ass. India.* 18(3): 84-87. (Quality Control Laboratory, CFTRI, Mysore 570 013, Karnataka).

Coconut oil samples stored in brown colour glass bottles at ambient temperature (18-32°C) is found more stable over its counterpart stored in colourless glass bottles. Oxidation effect could not be seen in both these oils until twenty eight months of storage.

**1092. PAI, J.S.; LOMANNO, S.S. and NAWAR, W.W.** 1979. Effect of heat treatment on the volatile composition of coconut oil. *J. Am. Oil Chem. Soc.* 56(4): 494-497. (Dept. of Food Science and Nutrition, University of Massachusetts, Amherst, M.A. 01003 USA).

Fresh coconut oil on heating either in vacuum or in air or in air and water gave out a series of volatiles, including n-alkanes, 1-alkenes, n-alkanals, methyl alkanones, alkenals,  $\gamma$ - and  $\delta$ -lactones, methyl and ethyl esters and free fatty acids. The relative amounts of these compounds varied with the type of heat treatment.

1093. PANTULU, A.J. 1983. Studies on the hydrogenolysis of coconut oil methyl esters to fatty alcohols using mixed metal oxide catalysts. *In: National Catalysis Symposium, 5th, 1980. Proceedings of the symposium. p.296-302. (RRL, Hyderabad 500 009, A.P.).*

The reaction rate is independent of the ester concentration in the reduction of methyl esters of coconut oil fatty acids to fatty alcohols in the presence of mixed metal oxide catalysts. The catalyst composition effects the catalytic activity.

1094. PAUL, P.G.; WILSON, K.I.; SAM RAJ, J. and PHILIP, SUSAMMA. 1979. Utilization of different vegetable oils by fungi, associated with the deterioration of copra. *In: Symposium on Plantation Crops, 2nd, Jun. 26-29, 1979. Proceedings of PLACROSYM II. Edited by C.S. Venkataram and others. p.367-371. (College of Agric., KAU, Trivandrum 695 522, Kerala).*

The utilization of vegetative oils viz., coconut oil, gingelly oil and ground nut oil by the fungi associated with copra deterioration was studied by replacing the carbon source of two synthetic media viz., Richard's solution and Czapek's solution. All fungi except *Rhizopus* sp. could use oil as a carbon source. The fungi preferred different oils depending on the medium.

1095. PHILIP, S, USAMMA. 1978. Need for rigorous standards on quality of coconut oil and copra used for edible purposes. *In: Seminar on Quality Control of Processed Foods. Proceedings of seminar. p.73-74. (College of*

*Agric., KAU, Trivandrum, Kerala).*

The microbial spoilage of copra and their influence on the quality of oil is discussed with relevance to laboratory inoculation, study on copra with ubiquitous fungi like *A. niger* and *A. flavus*.

1096. PHILIP, SUSAMMA and MENON, M.R. 1984. Changes in the properties of coconut oil due to storage. *Indian Cocon. J. 14(9): 39-40. (College of Agric., KAU, Trivandrum 695 522, Kerala).*

The changes in physical and chemical properties of coconut oil due to prolonged storage have been assessed by determining colour, odour, refractive index, acid value and iodine value at 3 month intervals for 12 months. The possible chemical reactions responsible for these changes have been discussed.

1097. RAMAMURTHY, M.K. and BHAT, G.S. 1976. Iodine number determination of milk fat and vegetable fats by refractometry. *J. Am. Oil Chem. Soc. 53(9): 577-580. (Southern Regional Station, NDRI, Hosur Road, Bangalore, Karnataka).*

A refractometric method for the estimation of iodine number of milk fat, coconut fat or other vegetable fats has been suggested. About 0.2 ml of fat was iodinated with a 10 ml Wij's iodine reagent for 3 min. using mercuric acetate as catalyst. The iodinated fat showed higher refractive indices and a very high correlation with the iodine values of the fats ( $r=0.9993$ ). The average of the ratios of change in refractive index to iodine number of fat can be calculated. The ratio for coconut fat was similar to that of milk fat.

1098. RAO, S.D. T. 1982. Coconut palm and palm kernel oils; a comparison. *Indian Cocon. J. 12(6-9): 21-26. (Oil Technological Research Institute, Ananthapur, A.P.).*

This paper presents a comparison of

important characteristics and standards in different countries in respect of coconut oil, palm oil and palm kernel oil.

1099. REDDY, N.C. GANGI; REDDY, OBI; ATCHUTHA D. RAMAYYA; AZEEMODDIN, G. and RAO, S.D.T. 1983. Coconut palm and palm kernel oils; a comparison. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, Edited by N.M. Nayar. New Delhi: Wiley Eastern. p. 274-278. (Oil Technol. Research Institute, Anantapur, A.P.).

A comparison of important characteristics and standards in different countries for coconut oil, palm oil, and palm kernel oil is presented.

1100. SATHYAVATI KRISHNAN KUTTY; BALACHANDRAN, C.; KRISHNASWAMY, C. and SREEMULANATHAN, H. 1980. Studies on improving the storage life of coconut oil. In: Symposium on Plantation Crops, 3rd, CIFT, Cochin, Dec. 12-15, 1980. Proceedings of PLACROSYM III. Edited by K.V. George and others. p.180-186. (RRL, Trivandrum, Kerala).

Vacuum heating of coconut oil at 130 to 150°C for 30 minutes was beneficial in preventing rancidity.

Storing the oil in brown bottles was found to improve the stability and prolong its shelf-life. Addition of antioxidants like butarylated

hydroxyanisole and propyl gallate showed slight beneficial effect.

1101. SREEMULANATHAN, H.; KRISHNASWAMY, C.; SATHYAVATHI KRISHNAN KUTTY and MATHEW, A.G. 1978. Recovery of coconut oil from rotary oil mill foots. *Indian Cocon. J.* 8(11): 5-7. (RRL, Trivandrum, Kerala).

The foot oil generally recovered by heating the foots to a high temperature and pressing in a crude screw press is dark coloured and used as a cheap lubricant. Clear and light coloured foot oil can be obtained by mixing with coconut cake in the ratio 1:2 and solvent extracting the mixture.

1102. THAMPAN, P.K. 1984. The present status and future requirements of R & D in the post-harvest processing of coconut in India. *Indian Cocon. J.* 14(9): 3-17. (Coconut Development Board, Cochin, Kerala).

The article deals with the inadequacy of technological research in the field of coconut product diversification and by-product utilization in India. The technological advances achieved by other countries in this respect and the necessity of establishing a Technological Development Centre in India to promote such technological research which is essential in ensuring the stability in coconut based economy are given in brief.

### 13.3 Coconut Pith

1103. ALI, A. ASLAM. 1983. Activiated carbons from coir fibre pith. In: Coconut research and development; proceedings of the international symposium, 1st, CPCRI, Kasaragod, Dec. 27-31, 1976, edited by N.M. Nayar. New Delhi : Wiley Eastern. p. 279-283. (Karnataka Carbons Pvt. Ltd., 510, V Block Jayanagar, Bangalore, Karnataka).

The technological feasibility of producing activated carbons from coir fibre pith obtained from coir factories was studied. The surface areas, adsorptive capacities and mechanical strength of differrent samples were determined. Methods by which the adsorptive capacities could be increased are discussed.

1104. ALI, A. ASLAM and BHASKAR, T.D. 1980. Utilization of coconut pith for the manufacture of oxalic acid. *Coir Quart. J.* 24(2): 9-11. (Karnataka Carbons Pvt. Ltd., Bangalore, Karnataka).

The authors describe a fine experimental method to extract oxalic acid from coconut pith in the form of crystals. Also includes a list of names and addresses of oxalic acid manufacturers in India.

1105. IDUCULLA, ROSCHEN. 1983. Micro-structure and water absorption mechanism of coconut pith. *J. Chem. Tech. Biotechnol.* 33A: 439-445. (RRL, Trivandrum, Kerala).

The water sorption isotherm of coconut pith is studied in order to get an insight into the nature of the sorption process which was found to be similar to that of other woody materials. The surface area available for absorption, heat of absorption and approximate size of possible capillaries are computed from the isotherm. A considerable hysteresis effect is observed. The cell structure of coconut pith is studied using an optical microscope.

1106. IDICULLA, ROSCHEN and SESHADRI, S.K. 1982. Desiccant characteristics of coconut pith. *J. Chem. Tech. Biochem.* 31(12): 1065-1072. (RRL, Trivandrum, Kerala).

The capacity, rate and efficiency of moisture adsorption by coconut pith was studied for using it as a desiccant. Its properties were compared with those of standard desiccants, especially silica gel, including regeneration characteristics. It is concluded that coconut pith is a cheap, yet effective desiccant.

1107. MENON, V.M. 1987. Commercial exploitation of coconut pith. *Indian Cocon. J.* 12(3): 3-5 (Mechanical Engineering Res. and Development Organisation - MERADO, Cochin 683 109, Kerala).

For effective utilization of coconut pith, a rotary type briquetting for small unit machine and a mechanical extender to form continuous briquettes for large unit, were developed. To improve the calorific value and bounding strength, various types of additives and binders in different combinations and proportions were tried.

1108. MOHAN DAS, P.N. 1983. Reduction of iron ore and millscale using coconut pith and coconut shell as reductants. *Trans. Indian Inst. Metals.* 36(1): 20-28.

The possibility of using coconut pith and shell (which are abundantly available agricultural materials) for reduction of iron ore and millscale is explored. Upto 95% reduction to metal takes place in about 3 to 4 hours at 1000°C. Chemical analysis of the reduced metal shows that pith and shell as well as their chars could produce sponge iron from iron oxide and millscale.

1109. NAGARAJAN, R.; MANICKAN, T.S. and

KOTHANDARAMAN, C.V. 1987. Coir pith as manure for groundnut. *Coir* 31(2): 15-18. (Dept. of Soil Science and Agric. Chemistry, TNAU, Coimbatore, T.N.).

A field experiment was carried out to evaluate the usefulness of coir pith (a waste from the coconut husk in coir fibre industry), as manure for groundnut crop in sandy loam soils in Agricultural Research Station, Aliyarnagar. Groundnut, CO 1, was sown with 12 treatments consisting of absolute control, N, P, K., NPK together and in combination with coir pith and inoculated coir pith with *Pleurotus* sp. a fungus, at 12.5 t/ha. The highest yield of pod (2486 kg/ha) was registered in coir pith inoculated and applied along with NPK which is 38 and 19 per cent increase over absolute control and NPK treated plots respectively. The increase in yield of pod might be due to the release of nutrients from the coir pith to the better growth of crops leading to higher production of pods. The above results were also confirmed by a subsequent field trial with groundnut in Aliyarnagar.

1110. RADHIKA, L.G.; SESHADRI, S.K. and MOHANDAS, P.N. 1983. A study of biogas generation from coconut pith. *J. Chem. Tech. Biotechnol.* 33B: 189-194. (RRL, Trivandrum, Kerala).

A combination of 60% coconut pith and 40% cowdung could produce considerable amount of biogas, which contained higher methane content as compared to the biogas from cowdung alone. Partial removal of lignin increased the rate of biogas production.

1111. RAMASWAMY, K. and GOWDER, K.R. KARAI. 1987. Coir pith as an insulating material for chulhas. *Indian Cocon. J.* 18(12): 5-7. (Dept. of Agric. Engineering, College of Agric. Engineering, TNAU, Coimbatore, T.N.).

Coir pith can be used as an insulation material and as a fuel in the conventional fire

wood stone, called Chulhas. The coir pith ash can be used as a manure. Also, it protects natural environment by preventing the cutting of trees for firewood purpose.

1112. SATYANARAYANA, K.G.; KULKARNI, A.G. and ROHATGI, P.K. 1983. Retrospect and prospect of natural fibres. *J. Sci. Indus. Res.* 42(8): 425-428. (RRL, Trivandrum, Kerala).

The article deals with information gathered through a questionnaire designed to elicit the views of natural fibre industries and R & D institutions dealing with natural fibres with regard to quality and quantity source and availability of products developed, waste utilization and possible new uses. Research imperatives based on this exercise are listed.

1113. SINGARAVELU, M.; SWAMINATHAN, K.R. and GOTHANDAPANI, L. 1988. Activated carbon from agricultural waste. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers.* p.32-33. (College of Agric. Engineering, TNAU, Coimbatore 641 003, T.N.).

A process for making activated carbon from coconut shell and coir pith is described. The recovery of activated carbon has been found to be 25% from coir pith and 17% from coconut shell.

1114. VARMA, D.S.; VARMA, MANIKA and VARMA, I.K. 1984. Coir fibres; part I: Effect of physical and chemical treatments on properties. *Text. Res. J.* 54(12): 827-832. (Dept. of Textile Technology, Indian Institute of Technology, New Delhi 110 016).

The effect of physical and chemical treatments on the mechanical properties of coir fibres is reported. Changes in moisture regain, crystallite orientation and percentage crystallinity were observed when fibres were treated with hydrochloric acid (10%), sodium hydroxide

## 13.4 Coir

1115. BHAT, J.V. 1983. The fibre from coconut fruits. In: Coconut research and development; Proceedings of the international symposium, 1st, CPCRI, Kasaragod Dec. 27-31 1976, edited by N.M. Nayar. p.259-273. (Dept. of Microbiology, Kasturba Medical College, Manipal 576 119, Karnataka).

The method of extraction of coir fibre in India through the retting (fermentation) of husks is explained.

The microorganisms associated with retting are the predominant gram negative short rods and yeasts. The species that decompose pectic substances are those belonging to the genera *Achromobacter*, *Alcaligenes*, *Aerobacter*, *Escherichia*, *Pseudomonas*, *Paracolobactrum*, *Micrococcus*, *Bacillus*. Yeast species of *Candida*, *Cryptococcus*, and *Rhodotorula* have also been reported to possess the ability to attack pectic substances. *Debaryomyces hansenii*, a yeast, is a powerful species in its ability to degrade phenolics. The *Micrococcus* species isolated likewise, is equally efficient and capable of even forming 3, 4, 3', 4' -tetrahydroxy diphenyl from catechol.

Several factors influencing retting have been detailed. Precrushing of husks before steeping them in water, aeration, and flushing of ret liquor hasten retting. Methods to improve retting process have been suggested.

1116. COIR DEVELOPMENT, TRIVANDRUM. 1981. Coir industry in Kerala. *Coir J.* 25(4): 5-7.

The author discusses the importance of the traditional coir industry in Kerala as a source of employment and a foreign exchange earner. Several obstacles for the progress of the coir industry have been outlined. Need to expand the marketing facilities is stressed.

1117. DEBNATH, C.R. and GHOSH, S.K. 1983. Physical properties of coconut fibrous sheath. *Indian Cocon. J.* 14(2): 3-5. (JTRL, 12 Regent Park, Calcutta, W.B.).

The coconut sheath consists of closely woven fibrous structure. The face surface of the structure consists of coarser fibres which intersects with the finer fibres of the back surface of the structure at an angle of about 40°C. The tensile strength of fibrous sheath was measured on Instron Tensile Strength Tester. The values of tenacity and extension at break of the fibrous sheath varied between 0.32 and 1.8 g per tex and 1.5% and 6.5% respectively when they were measured at 20° to 180° towards the coarser fibres.

1118. DINESH, E. 1987. Coir; an industry in search of viability. *Ceres* 20(4): 32-34. (Dept. of Management, Vaikunth Mehta National Institute of Co-operative Management, Pune, Maharashtra).

The coir industry has potential for development in coconut growing countries of Asia and Africa, particularly in India, Sri Lanka and other South and Southeast Asian Countries. The paper discusses employment generation by the coir industry with special attention to the Indian experience. It is concluded that there is a need for an institutional structure for production and marketing of coir products within the country.

1119. JAYASANKAR, N.P. 1978. Perspectives on the biological extraction of coir. *Indian Cocon. J.* 9(2): 1-3. (CPCRI (RS), Kayangulam, Kerala).

The age old practice of biological extraction of coir consists essentially of soaking coconut husks in water for varying lengths of time. Salinity and periodical flushing of the

ret liquor are considered by the retters as pre-requisites for the production of good quality of coir fibre. Vast amount of data is available on the bacteria and yeasts associated with the retting process. Polyphenols of the coconut husk delay the completion of the process.

1120. KULKARNI, A.G.; SATYANARAYANA, K.G. and ROHATGI, P.K. 1983. Studies on moisture absorption in coir fibres (*Cocos nucifera* Linn.) *J. Appl. Polym. Sci.* 28(2): 625-632. (RRL, Trivandrum, Kerala).

Moisture desorption and absorption characteristics in coir fibres have been studied at several temperature (53°C, 68°C, 86°C and 105°C) as a function of time. The relation between percentage moisture loss (A) and temperature (T°K) is of the type  $A = A - B/T$  in the range of intervals studied. The constants A and B decrease with time. The equilibrium moisture content increases with increase in relative pressure and decrease in temperature. As the moisture content in the fibre increases, the tensile strength (tenacity) decreases and the % elongation increases. The observed results are explained on the basis of structural rearrangement on heating/cooling of ligno-cellulosic material.

1121. KULKARNI, A.G.; SATYANARAYANA, K.G. and ROHATGI, P.K. 1983. Weibull analysis of strength of coir fibres. *Fibre Sci. Technol.* 19: 59-76. (RRL, Trivandrum, Kerala).

The large scatter observed in the fracture strengths of coir fibres ranging in length from 0.001 m to 0.065 m and in diameter from  $0.15 \times 10^{-3}$  to  $0.35 \times 10^{-3}$  m, is analysed statistically using a two-parameter weibull treatment. The strength distribution at any length (and for any diameter of fibre) can be represented satisfactorily by unimodal weibull distributions. The plot on logarithmic coordinates of mean fracture strength (=  $f$ ) against test length for a  $0.25 \times 10^{-3}$  m diameter coir

fibre, shows a linear relationship between 0.065 m and 0.006 m. At 0.006 m the strength is relatively independent of length and below this length, the flaws are evenly distributed.

The increase in Weibull parameter,  $m$  with increase in diameter results in uniform flaw distribution. The origin of flaws in coir fibres may be from two sources (a) growth defects and (b) processing defects. These flaws and flaw distributions in coir fibres are responsible for the observed scatter in fracture strength values.

1122. KULKARNI, A.G.; SATYANARAYANA, K.G.; SUKUMARAN, K. and ROHATGI, P.K. 1981. Mechanical behaviour of coir fibres under tensile load. *J. Meter. Sci.* 16: 905-914. (RRL, Trivandrum, Kerala).

Stress-strain curves of coir fibres have been determined. Mechanical properties including initial modulus, strength and percentage elongation of coir fibres have been evaluated as functions of retting treatment, fibre diameter, gauge length and strain rate. Retted and unretted fibres upto a fibre diameter of  $0.2 \times 10^{-3}$  m had similar mechanical properties. On the other hand modulus values and percentage elongation have been related to micro-fibrillar angle and strength value to the fibre diameter. Scanning electron microscopy indicated that the failure of the fibre is due to the fracture of the cells themselves accompanied by the uncoiling of microfibrills. There is no appreciable variation in strength and percentage elongation with strain rates for any one diameter of the fibre. On the other hand, with increase in gauge length, a decrease in both strength and percentage elongation at break has been observed. These have been attributed to an increase of probability of defects and localised deformation and gentle necking, respectively.

1123. MATHEW, CHANDY P. 1988. Rubberised

coir industry; an introduction. *CORD* 4(1): 66-73. (Duroflex Coir Industries Pvt. Ltd., Bangalore, Karnataka).

Utilization of coconut namely coconut fibre or coir for production of rubberised fibre is discussed.

1124. NAGARAJAN, R.; DAS, ANITA, RABINDRANATH and PRABHU, G.N. 1987. Studies on seeding of ret microflora on coconut husks. *Coir* 31(2): 9-11. (Central Coir Research Institute, Kalavoor, Kerala).

Coir fibre of good quality is extracted from coconut husks after retting the husks for 6-10 months in saline back waters. The quality of the fibre is mostly determined by the progress of retting involving the elimination of binding material and phenolics by the action of microflora. The scope for speeding up the retting process and bettering the quality of coir fibre by seeding microflora has been investigated by field experiment. The experiments reveal that inoculation of ret microflora mass multiplied in the laboratory on collection from areas known for good retting, to stocks of husks steeped for retting in regions known for poor retting leads to bettering the colour of the fibre, besides reducing the period of retting.

Data on the dissimilation of pectin and phenol and variation in microbial population with the progress of retting are presented in this paper.

1125. NAGARAJAN, T.S.; MANICKAN, T.S. and KOTHANDARAMAN, C.V. 1987. Composting coir dust for better utilization of agricultural farms. *Coir* 31(2): 12-14. (Dept. of Soil Science and Agric. Chemistry, TNAU, Coimbatore 641 003, T.N.).

A laboratory study was carried out by treating the coir pith with *Pleurotus* sp. and urea and incubated at room temperature for 26 days. Biochemical analysis of raw and

decomposed coir pith has shown a definite reduction in lignin and cellulose contents with an increase in total nitrogen and other nutrients. The C:N ratio was narrowed down from 112:1 to 24:1 indicating the feasibility of using the inoculated coir pith as manure in agricultural farms.

1126. PAVITHRAN, C. 1981. Copper coating on coir fibres. *J. Meter. Sci.* 16(6): 1548-1556.

Conditions for obtaining continuous coatings of Cu (thickness 1.5 - 5  $\mu$ m) on coir fibres were determined. Activation of the surface of the coir fibres was achieved by treating the surface of the fibres with NaOH-HCHO/ammonical AgNO<sub>3</sub> solution. The effects of variation in HCHO and NaOH concentrations and pressures inside the coating vessel on deposition rates were determined. The minimum concentrations of NaOH and HCHO required for maximum rate of deposition of Cu from a solution containing 10 g/l CuSO<sub>4</sub> were 6.6 g/l and 2.5-3.5 g/l respectively. Optical and scanning electron microscopic studies showed that relatively more uniform and nonporous Cu coating were obtained under reduced pressures. A 5  $\mu$ m thick Cu coating on coir fibre prevents the propagation of flame as was shown by flammability tests. Cu coating on coir fibre decreased its electric resistivity from 2.55x10<sup>-6</sup>  $\mu$  cm to 4.68x10<sup>-6</sup>  $\mu$  cm with a 1.5/ $\mu$  m thick coating and 3.76x10<sup>-6</sup>  $\mu$  cm with a 5/ $\mu$  m thick coating.

1127. PRABHU, G.N. 1977. Studies on coir extraction, spinning, bleaching and dyeing. *Coir* 21(3): 210-11 (CPCRI, Kalavoor, Alleppey, Kerala).

The paper describes the outcome of investigations on process improvement in coir extraction, softening, bleaching and dyeing including the extraction of 'white' coir fibre and modified method of separation of fibre from retted husks.

1128. PRABHU, G.N.1978. Studies on coir extraction, spinning, bleaching and dyeing. *Coir* 22 (3):7-11. (CPCRI, Kalavoor, Alleppey, Kerala).

The paper deals with the experiments conducted in the bleaching and dyeing of coir fibre, to improve the methods for commercial exploitation. Results of the light fastness test for evaluating the dye uptake and the list of different dyes are also given.

1129. PRASAD, S.V., PAVITHRAN, C. and ROHATGI, P.K. 1983. Alkali treatment of coir fibres for coir-polyester composites. *J. Meter. Sci.* 18: 1443-1454. (RRL, Trivandrum 695019, Kerala).

Coir fibres were subjected to alkali treatment by a commercial resin like polyester to improve its wettability. Tensile strength of the fibres increased by 15% when the fibres were soaked in 5% aqueous solution of NaOH at  $28\pm 1^\circ\text{C}$  for 72 to 76 h after which it showed a gradual decrease.

The removal of cuticle and tyloses, during alkali treatment, resulted in a rough fibre surface with regularly spaced pits. The debonding stress of alkali treated fibres from polyester matrix was 90% higher than that of untreated fibres from the same matrix. Porosity, flexural strength, modulus and impact strength of composites containing alkali treated fibres were 40% higher than the untreated fibres, in addition to less fibre segregation and better fibre-matrix bonding.

1130. RAMACHANDRAN, T.V. 1981. Rubberised coir Industry. *Coir* 25 (8): 5-6. (All India Rubberised Coir Products Manufacturer's Association, Kerala).

The importance of Rubberised Coir Industry, the process of manufacture in India with its major products and their uses are outlined.

1131. RAMASWAMY, K.; GOWDER K.R. KARAI and SWAMINATHAN, K.R. 1988. Coconut coir reinforced roofing sheets for farm buildings. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.51. (College of Agric. Engineering, TNAU, Coimbatore 641 003, T.N.).*

A technology for coconut coir reinforced corrugated cement roofing sheets was developed for farm buildings in place of corrugated asbestos, steel and aluminium roofing sheets. 1.5 m x 1.0 m size sheet was found to be optimum for maximum breaking strength (3.5 kg/cm). The coefficient of thermal conductivity, weight of the sheet, water permeability, cost etc. were estimated and compared with the asbestos roofing sheets. A few model sheds constructed with coir-cement roofing and indoor climatic conditions has been evaluated for poultry growth and yield performance. Yield parameters like mean weight gain, egg weight, egg yield, water intake etc. were better in coir cement roofing compared to the similar asbestos sheet. The cost of 1 sq. m. roofing works out to Rs. 30 which is 50 per cent cheaper than the asbestos sheet roofing.

1132. RAMASWAMY, K.; GOWDER, K.R. KARAI and SWAMINATHAN, K.R. 1988. Coir netting in ferrocement members. *In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstracts of papers. p.49. (College of Agric. Engineering, TNAU, Coimbatore 641 003, T.N.).*

A unique ferrocement technique involving steel fibres in conjunction with coconut coir fibre had been developed. Additional flexural strength of 250 tonnes could be obtained by the intrusion of 0.4 kg coconut coir per one square metre surface area over the conventional sole steel fibre reinforcement in ferrocement slabs. A storage water tub of 1050

litre capacity for drinking water purpose of cattle had been fabricated and evaluated. The tank is intact for the past two years, which is 47% more economical than similar capacity storage tub with brickwork.

1133. RAMASWAMY, K.; GOWDER K.R., KARAI; SWAMINATHAN, K.R. and KUPPUSWAMY, S. 1988. Economical coir reinforced floor slabs for cattle sheds. In: National Symposium on Coconut Breeding and Management, KAU, Vellanikkara, Trichur, Nov. 23-26, 1988. Abstract of papers. p. 50. (College of Agric. Engineering, TNAU, Coimbatore 641 003, T.N.).

An intermediate technology has been developed to prefabricate coir reinforced floor slabs for cattleshed in place of expensive concrete flooring and to replace unhygienic mud flooring. Trials conducted on coconut coir reinforcement to improve modulus of elasticity and flexural strength showed that 400 g/m<sup>2</sup> area is found to be optimum. A prefabricated slab flooring of 4.5 sqm area was constructed and found to have no damage due to movement of cattle during the one year study period.

1134. REDDY, L. SHIVARAMA and THAMPAN, P.K. 1988. Commercial exploitation of coconut husk in Orissa. *Indian Cocon. J.* 19(3): 3-6 (Coconut Development Board Regional Office, No. 72, West Chord Road, 2nd Stage, Rajajinagar, Bangalore 560 086, Karnataka).

A study was undertaken in four major coconut producing districts of Orissa to find out the zonal differences on the weight of nut and husk and to estimate the quantum of husk available for commercial exploitation. Thus the total production of husk, if coconuts are harvested at proper maturity stages could be estimated at 91,204 tonnes which in turn will contribute 27,361 tonnes of coir fibre. The potential districts for production of coir in Orissa are Puri (46.12%), Cuttack (23.09%), Ganjam

(12.29%) and Balsore (10.83%).

1135. REMANI, K.N. 1981. Sediments of a retting yard. *Indian J. Mater. Sci.* 10(1): 41-44. (National Institute of Oceanography Regional Centre, Cochin 682 018, Kerala).

Sediments of a coconut husk retting yard and a reference station in Cochin backwaters were studied for 1 year. Organic carbon, organic matter, C/N ratio and average energy content were higher in the retting sediments, while annual average bacterial biomass and bacterial to total organics appeared higher in the reference station. Effect of monsoons was found significant.

1136. SATYANARAYANA, K.G.; KULKARNI, A.G. and ROHATGI, P.K. 1981. Potential of natural fibres as a resource for industrial materials in Kerala. *J. Sci. Ind. Res.* 40(4): 222-237. (RRL, Trivandrum, 695 019, Kerala).

The availability and present uses of some of the natural fibres, namely coir, banana, pineapple, palmyrah and screwpine, in Kerala are given. The currently used methods of extraction and grading and the available data on structures and properties of these fibres are reviewed. Research imperatives related to cultivation, extraction and processing of these fibres and potential new uses for them are indicated.

1137. SATYANARAYANA, K.G.; KULKARNI, A.G. and ROHATGI, P.K. 1981. Structure and properties of coir fibres. *Proc. Indian Acad. Sci. (Engg. Sci.)* 4(4): 419-436. (RRL, Trivandrum, Kerala).

In this paper, early research on the structure and properties of coir fibres has been critically reviewed. Additional informations on the evaluation of mechanical properties (as functions of the retting process, fibre diameter and gauge lengths of fibre, as well as of the strain rates) and fracture mechanisms using

optical and scanning, electron microscopy are given. The deformation mechanism of coir fibre is discussed. Suggestions for further work including effects of mechanical, thermal, thermomechanical and chemical treatments to modify the structure and properties of fibre are presented.

**1138. VENUGOPAL, B.; PILLAI, C.K.S. and SATYANARAYANA, K.G. 1990. Studies on flame**

retardance of needle felt coir mat. *Res. Industry* 35 C: 108-110. (RRL, Trivandrum 695 019, Kerala).

This paper presents results of studies made to arrive at an industrially applicable, durable and inexpensive fire retardant process for coir and coir products, especially the needle felt coir mat.

(10%), and acetic acid (10%). Scanning electron micrographs of the fractured surfaces of the fibres showed extensive fibrillation. Tenacity and elongation-at-break decreased with chemi-

cal treatment and UV irradiation. An increase in initial modulus and crystallinity was observed with alkali treatment.