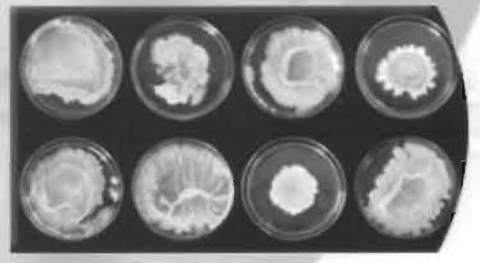
अनुसंधान विशेषताएँ
Research Highlights
2010 - 11



केन्द्रीय रोपण फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
कासरगोड - 671124, केरल, भारत
Central Plantation Crops Research Institute
(Indian Council of Agricultural Research)
Kasaragod 671 124, Kerala, India

अनुसंधान विशेषताएँ

RESEARCH HIGHLIGHTS

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कासरगोड़, केरल - 671 124

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE

(Indian Council of Agricultural Research)

KASARAGOD 671 124, KERALA, INDIA

CPCRI. 2011. Research Highlights 2010-11
Central Plantation Crops Research Institute
Kasaragod, Kerala, India. 36 p.

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February 2011

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Mr. C. H. Amarnath
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Cover photo
1. Guinea grass intercropping under coconut
2. Coconut Nursery
3. PGPR isolates from coconut based cropping system
   Back cover : Prof. K.V. Thomas interacting with trainees at KVK, Kasaragod

Hindi Translation
Dr. (Mrs.) Alka Gupta
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प्रस्तावना

इस संस्थान की मुख्य फसलों के अनुसंधान एवं प्रौद्योगिकी हस्तांतरण कार्यक्रमों पर वर्ष 2010-11 की अवधि में प्राप्त की गई प्रगति एवं उपलब्धियों को सारगर्भित रूप में इस प्रकाशन में प्रस्तुत किया है ।

जैव विविधता संसाधनों पर लक्षित समान्वेषण से अनन्य प्रकार युक्त विशेष परीक्षण के साथ फसल सुधार के लिए आनुवंशिक आधार को समृद्ध बनाने को साध्य बनाया गया । लंबित अवधि के संकर परीक्षण से प्राप्त किए गए आँकड़े विषममय व्यवहार प्रदर्शनी में विशेष संयुक्तों की श्रेष्ठता पर सूचनाएँ प्रदान की गई है । जैव प्रौद्योगिकीय और जैव सूचनात्मक उपकरणों का प्रयोग संकटपूर्ण समस्याओं का हल निकालने की प्रौद्योगिकियों के अधिक विकास में उपयोगी हो गया । विभिन्न सस्य जलवायु क्षेत्रों के लिए फसलन पद्धति मॉडलों की व्यवहार्यता अधिक प्रमाणित किया गया । जैविक पद्धति और व्यूहाण्वीय पहुँच की भूमिका के माध्यम से पौध लाभदायक अणुजीवों और उनके लाभदायक परीक्षणों की विभिन्नता पर सूचनाएँ प्रबल बनायी जा रही हैं । समीकृत कीट प्रबंधन प्रोटोकॉल परिष्कार का प्रयास मूल कीट के नियंत्रण की उत्तम क्षमता के साथ नए व्यूहाणुवों के पहचान में परिणत हो गया । उपज विविधीकरण, डी एफ आर एल के साथ सहजीविता भागीदारी वरजिन नारियल तेल की पोषकीय और स्वास्थ्य लाभ के जैसे नई सूचनाएँ उत्पन्न करने में सिद्ध पायी गयी । अनुसंधान विस्तार कृषक अभिमुख को बढ़ावा देने के लिए मोबाईल वीडियो सम्मेलन पद्धति की सुविधा के साथ प्रौद्योगिकी हस्तांतरण अधिक प्रबल बनाया गया ।

संपन्नता के लिए नारियल जैव विविधता पर अन्तर्राष्ट्रीय सम्मेलन 11 देशों की प्रतिभागिता के साथ आयोजित किया गया और फसल के सामने चुनौतियों और वैश्विक परिदृश्य को देखते हुए नारियल सुधार के लिए रण नीतियाँ रूपांकित की गयी ।

मैं सभी का आभारी हूँ जिन्होंने विज्ञान की उन्नति और कृषक समुदाय के हित के लिए महत्वपूर्ण योगदान दिया है ।

जी. वी. थॉमस

फरवरी, 2011

(डॉ. जॉर्ज. वी. थॉमस)
निदेशक

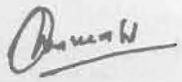
PREFACE

An overview of research achievements and progress made by the Institute on research and transfer of technology programmes on the mandate crops during the year 2010-11 are presented in this publication.

Targeted exploration of biodiversity resources enabled to enrich the genetic base for crop improvement with unique types possessing specific traits. Data generated from the long term hybrid evaluation trails have provided information on the superiority of specific combinations in exhibiting heterotic behaviour. The application of biotechnological and bioinformatics tools enabled to advance further in the development of technologies to address the critical issues. Viability of cropping system models for different agro - climatic regions have been further substantiated. Information on diversity of plant beneficial microbes and their beneficial traits have been strengthened through the introduction of biolog system and molecular approaches. Efforts to refine the integrated pest management protocol resulted in identifying new molecules with better efficiency to control the key pests. In product diversification, consortium partnership with DFRL enabled to generate new information as the nutritional and health benefits of virgin coconut oil. Transfer of technology is further strengthened with the addition of mobile video conferencing system to promote research-extension-farmer interface.

An International Conference on Coconut Biodiversity for Prosperity was organized with the participation of 11 countries and formulated strategies for coconut improvement considering the global scenario and challenges faced by the crop.

I take this opportunity to thank all those involved in delivering these important contributions for the advancement of mandate crops of the institute for the benefit of the farming community.



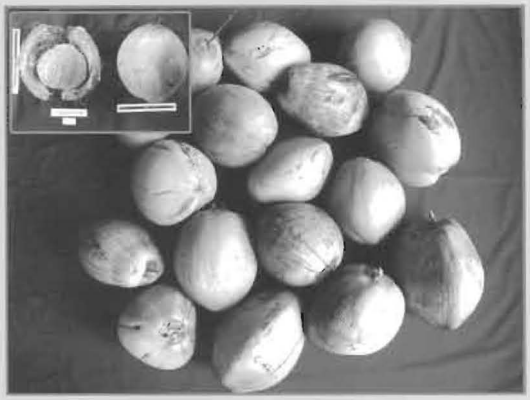
February, 2011

(Dr. George V. Thomas)
Director

CROP IMPROVEMENT

Genetic resources conservation and utilization

Germplasm exploration undertaken in Bhagalpur, Katihar and Poornia districts of Bihar has resulted in collection of three cold tolerant coconut accessions. A coconut palm free from leaf eating caterpillar infestation amidst the heavily infested palms was located in Karnataka and nuts collected for conservation. A large fruited coconut accession was collected from a farmer's garden in Vaibhavwadi Tehsil, Sindhudurg district of Maharashtra.



Coconut accession collected from Vaibhavwadi, Maharashtra

Cold tolerant coconut accession collected from Bihar

Five local ecotypes *viz., Jappanam* from Alleppey district of Kerala and *Kalache, Yana, Devarmute* and *Mavinkuruva* from Uttar Kannada District of Karnataka were further selected for *in situ* characterization.

A high yielding micro tall selection from IND067 population at Kidu

Besides, the embryo cultured seedlings of *Mahacho Naral* coconuts (sweet kernel coconut) were handed over to AICRPP Centre, Bhatye for field planting.

Evaluation of coconut germplasm under different trials has indicated that the accessions, IND045, IND001S, IND083S, IND085S, IND071S, IND059S, IND034S, IND090S, IND 004S, IND076, IND078 and IND080 are promising. An indigenous Yellow Dwarf selection and a high yielding Micro Tall selection from West Coast Tall population were identified for further studies.

A selection from IND045 is identified to be promising with early bearing nature (flowering 48-53 months after

planting) and higher average nut yield of over 110 nuts per palm per year under rainfed conditions. The fruits are green coloured, medium sized with an average endosperm content of more than 300g and copra content of 180-200g.

A high yielding selection from IND045

A compact block of IND099 selection, a promising dwarf coconut accession which has recorded an average copra content about 260g, was planted with the seedlings produced from the selected typical IND099 mother palms from WCGC, Andamans. Besides, compact blocks of two Orange Dwarf coconut selections made from IND112 and IND116 identified for early flowering, high nut yield and tender nut traits were also planted.

Among hybrid combinations being evaluated, IND058 x IND042, IND058 x IND125, IND007 x IND091, IND007 x IND018, IND007 x IND008, IND029 x IND008, IND029 x IND014, IND014 x IND003 and IND092 x IND069 showed better performance for growth, flowering and yield of nuts.

Indigenous orange and yellow accessions of coconut

A total of 300 S_1 progenies along with OP population were produced and 552 S_1 progenies (WCT = 124, LCT = 110, COD = 108, GBGD = 103 and MYD = 107) and 707 OP nuts were collected as part of efforts to develop Inbred lines in coconut. In order to develop S_3 population, selfing of WCT (S_2) x WCT (S_2) was under

A view of the coconut nursery at Kasaragod and arecanut nursery at Kidu

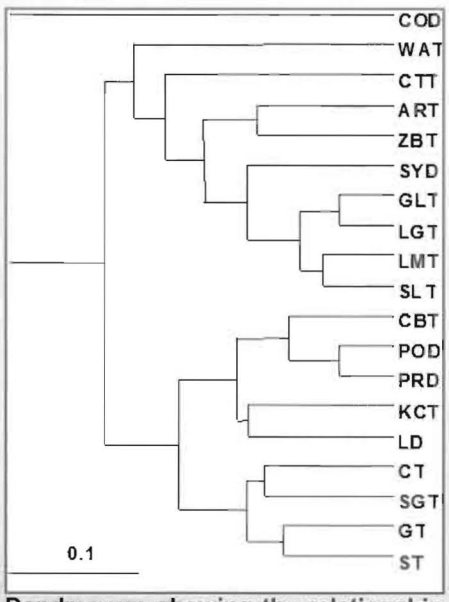
Accreditation for CPCRI nurseries

CPCRI nurseries at Kasaragod, Kidu and Vittal have been awarded with 'four-star' rating in the five-star scale by National Horticultural Board under the scheme to rate the horticultural nurseries in the country. The higher grade was awarded considering the availability of adequate infrastructure, mother gardens, expertise for quality planting material production and the excellent track record over the past decade. During 2010-11, the Institute has produced 101977 seednuts of different coconut varieties including 26193 hybrid nuts, 242651 areca seednuts/ seedlings and 121642 cocoa planting materials for distribution to farmers and different agencies.

BIOTECHNOLOGY

Molecular characterization of coconut germplasm

Molecular characterization of 18 Indian Ocean coconut germplasm collections with eight highly polymorphic microsatellite markers has shown that the maximum mean observed hetrozygosity value was in Sri Lankan Tall (SLT) population and lowest mean observed hertozygosity was in PRD and Laccadive Dwarf (LD) populations. In observed gene diversity the mean value ranged from 0.13 for POD to 0.53 for the Gonthambili (GLT) population among the 18 populations studied with an average of 0.32. Among the 8 loci studied, the primer CAC3 showed the highest gene diversity value of 0.73, while the primer CAC11 and CAC10 had a gene diversity value of 0.22. The maximum genetic distance (2.29) was



Dendrogram showing the relationship between the eighteen accessions of Indian Ocean Islands

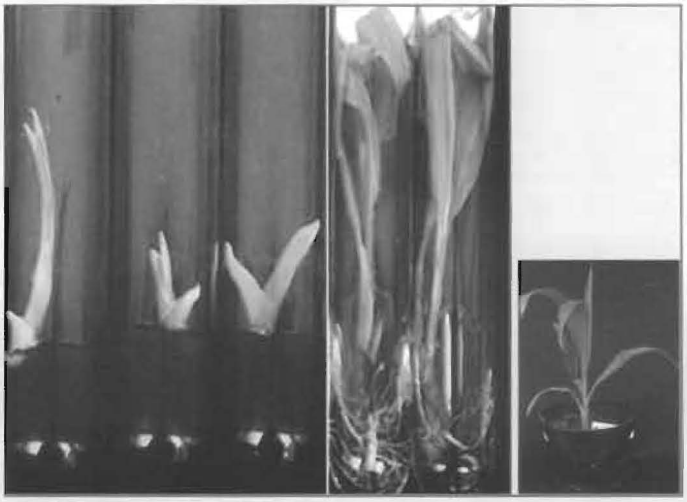
observed between Laccadive Green (LGT) and the control Chowghat Orange Dwarf (COD), minimum genetic distance (0.04) observed between Laccadive Micro Tall (LMT) and Sri Lankan Tall (SLT).

Coconut inflorescence culture

The young inflorescence culture has yielded plantlets arising from the relatively undifferentiated floral primordia. The attempts of culturing rachilla from disease - free palms was successful though it is a very slow and time consuming process. It is a four stage culture process in which cultures of the first three stages were to be maintained in the dark and then gradually brought to the fully illuminated condition when the plantlets turned green. During each of the stages, the transfer was made after assessing the progress of development and not arbitrarily after the four month period as the explants from different trees showed variation in the response time. Similar explants from root (wilt) affected palms did not survive even the first cycle of incubation in the dark. Several shoots produced by this process were transferred to various media for rooting.

Cryopreservation of coconut zygotic embryos by vitrification

Among the seven plant vitrification solutions (PVS1, PVS2, PVS3, PVS4, Steponkus, Towill and Fahy) tested, the PVS3 solution was found to be the most effective for regeneration of cryopreserved coconut embryos. The effect of preculture conditions, PVS3 vitrification, cryopreservation and unloading solutions on survival and regeneration of coconut zygotic embryos were standardized. The optimal protocol included preculture of embryos for 3 days on medium with 0.6 M sucrose, PVS3 treatment for 16 hours, rapid cooling and re-warming and unloading in 1.2 M sucrose liquid medium for 1.5 hours. Under these conditions, 75 % survival was observed with cryopreserved embryos and 22.5% of the plants regenerated from cryopreserved embryos have established in pots.

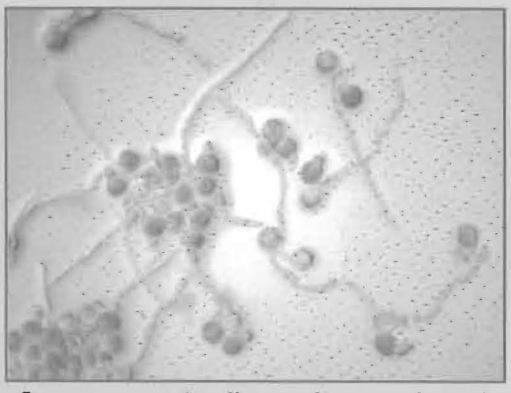


PVS3 treated and cryopreserved *in vitro* retrieved plantlets

Transmission Electron Microscopy (TEM) studies of meristematic region in PVS3 treated and cryopreserved

embryos under optimal conditions showed cells with intact cell wall, plasma membrane and dense cytoplasm filled with organelles.

Coconut pollen cryopreservation

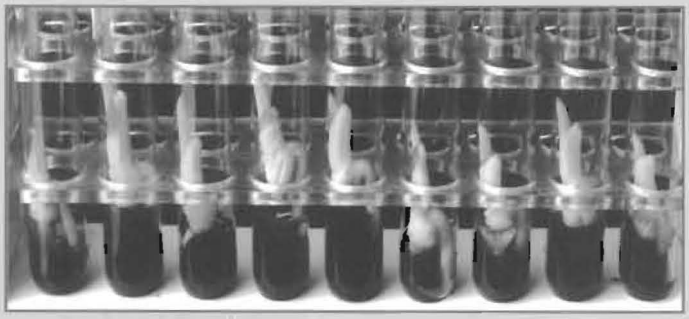


Cryopreserved pollen grains germinated after 90 minutes under *in vitro* culture

Cryopreserved pollen grains from IND069 and IND007 palms that were stored for 4 years (from 13th February 2007) retained viability of 63.62 and 39.69 % respectively as assessed by *in vitro* pollen germination. These cryopreserved pollen were also used for artificial pollination and normal nut set was observed in IND007 and IND069.

Mutation studies in coconut

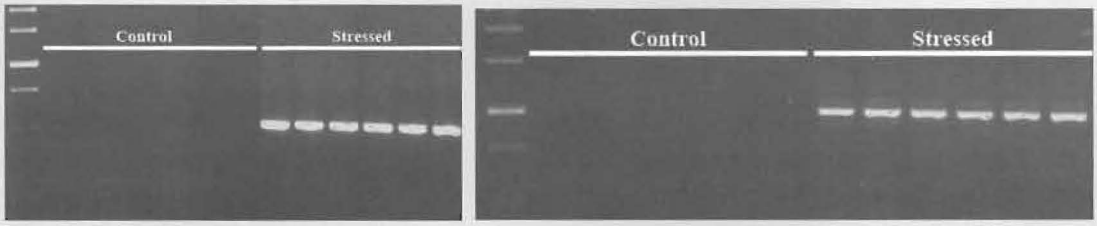
Studies on the effect of various concentrations of NaN_3 (2mM, 2.5mM, 3 mM, 3.5 mM and 4 mM) on germination of coconut zygotic embryos has revealed that the plumule and radical length decreased as the concentration of NaN_3 increased, and highly effective at concentrations 3.5 mM, and 4 mM, respectively. The LD 50 value of sodium azide for coconut embryo was 2.5mM.



Coconut zygotic embryos treated with 3.5 mM NaN_3

Cloning and identification of transcripts induced during water stress in coconut

The nucleotide and protein sequences pertaining to known genes induced during water stress *viz.* DREB, 14-3-3, aquaporins, 9-cis-epoxycarotenoid dioxygenase, WRKY, NAC and epicuticular wax (CER, GL and Wax) were retrieved from the NCBI. Nucleotide sequences coding for conserved domain amino acids were selected for oligomer designing. The degenerate primers were used to amplify putative water stress responsive genes in coconut via RT-PCR



Expression profiles of 14-3-3 and CBF analyzed by RT-PCR after subjecting coconut seedlings to water stress

(Reverse Transcription-polymerase chain reaction). Amplicons of expected sizes were eluted, cloned and sequenced. Positive sequences were deposited in Genbank.

Testing of coconut-specific RGA primers

From the sequences of RGAs from coconut using the degenerate primer-based cloning strategy previously obtained, gene-specific primers were designed to amplify RGAs in coconut. These primers were then used to amplify putative RGAs from root (wilt) resistant and susceptible West Coast Tall and Chowghat Green Dwarf cultivars of coconut. Amplicons of expected sizes were cloned and sequenced. A phylogenetic tree was constructed based on neighbour joining method. In general, the palms clustered according to their level of resistance or susceptibility.

Nucleotide sequence variation in somatic embryogenesis receptor kinase (SERK) gene in cocoa

Genomic DNA extraced from young cocoa leaves by DNeasy mini kit was quantified and among the EST-SSR markers amplified, seven markers (viz. TH 1, TH 2, TH 4, TH 8, TH 9, TH 10 and TH 11) produced amplicons of expected size. When screened with 12 cocoa accessions for level of polymorphism, 27 polymorphic alleles were produced which ranged from two to six alleles per locus with an average of 3.85 alleles per locus. The average polymorphism information content (PIC) value was 0.57. The similarity index, based on Dice coefficient, obtained after pairwise comparison among 12 cocoa accessions showed the highest index of 0.80 in the accessions, Jerangau Red Axil (JRA) and VTLC-1 and the lowest (0.111) was observed between VTLCP-22 and VTLCC-1. The dendrogram generated with cluster analysis separated the 12 cocoa accessions into two major clusters at 35% similarity level. The first major cluster had five sub-clusters and included nine accessions. Accessions JRA and VTLC-1 exhibited 80% similarity.

BIOINFORMATICS

In silico prediction of properties of KNOX and BABY BOOM proteins in coconut

Proteins known to be induced during somatic embryogenesis in coconut, *viz.* KNOX and BABY BOOM were characterized using bioinformatic tools. Sequence pattern recognition and determination of modular architecture were done by Interpro analysis based on PROSITE. Physicochemical properties of the proteins were determined using the PROTPARAM tools. Function assignments were made based on the structural homologues identified for the test proteins. 3-D structures were generated based on the secondary analysis. The structures thus obtained were assessed using PROCHECK.

Nucleotide sequence variation in somatic embryogenesis receptor kinase (SERK) gene in arecanut

Sequences encoding SERK were cloned and sequenced from embryogenic, non-embryogenic, friable and non-friable calli of arecanut using a degenerate primer-based PCR approach and sequences were deposited in NCBI. Sequence analysis revealed high levels of similarity to other plant SERKs. The nucleotide diversity in the SERK gene from the four different calli types was investigated. Sequence alignment and nucleotide polymorphism detection was performed. Each polymorphic site was visually checked on the chromatograms in order to distinguish true polymorphism from scoring errors. Basic parameters, including the number of single nucleotide polymorphisms (SNPs), insertions-deletions (INDELS), synonymous and non-synonymous mutations were calculated. A total of eight polymorphisms (three SNPs and five INDELs) were detected, mainly in the non-coding region.

Identification of microsatellites from fully sequenced genomes of plant growth promoting rhizobacteria (PGPR)

Genome-wide analysis was carried out to identify microsatellites from completely sequenced genomes of *Pseudomonas fluorescens* and *Bacillus subtilis*. SSRPredictor, a bio-java based powerful, stand alone platform was designed to allow the identification and characterization of microsatellites in the entire bacterial genome. Sequences flanking the detected microsatellite regions were then used to design primer pairs. Ten microsatellite- markers each were used for validation in different *Pseudomonas* and *Bacillus* spp.

SVM-based approach for the prediction and classification of enzymes involved in antibiotic biosynthetic pathways in plant growth promoting *Pseudomonas* species

A novel method has been developed for the prediction of enzymes involved in antibiotic biosynthetic pathways in plant growth promoting *Pseudomonas* species on the basis of amino

acid and dipeptide composition by using the Support Vector Machines (SVM). The performance of the system was achieved by using a training set consisting of non-redundant set of positively labeled enzymes involved in antibiotic biosynthesis pathway in *Pseudomonas* spp. and non-redundant set of negatively labeled sequences from other organisms obtained from NCBI. Based on the above methods, a web server has also been developed.

Support Vector Machine based web server in bioinformatics, homepage

Microsatellite markers in Cocoa

Microsatellite markers were identified from the cocoa EST sequences available on the public domain using bioinformatics tools (MISA, TRA, TROLL, SSRIT and SSR primer) and primer design was done by Primer3 tool. The identified markers were verified by wet lab experiments. Besides, 33 cDNA libraries of cocoa were analyzed using bioinformatics tools (Seqclean, TGICL, BLAST) and identified 11 important enzymes involved in ethylene, hypusine, acetaldehyde and polyamine biosynthesis pathways.

Functional annotation of cocoa EST sequences resulted in identification of Phenylpropanoid biosynthetic pathway enzymes including Caffeate O- methyltransferase, Acyltransferase, Coffeoyl- CoA O- methyltransferase, Cinnamoyl- CoA reductase and Cinnamyl alchohol dehydrogenase involved in drought stress response.

CROP PRODUCTION

Growing intercrops in coconut under coastal littoral sandy soils

Elephant foot yam as intercrop

Elephant foot yam as intercrop in coconut garden

In the field experiments on coastal sandy soil management, three different varieties of elephant foot yam (Gajendra, Padma and Local) were evaluated as intercrop in the coconut garden by adopting soil moisture conservation methods. The variety, Gajendra recorded higher corm yield (17.6 t/ha) which was on par with the local variety (16.7 t/ha) and significantly differed from Padma (14.5 t/ha). In the case of soil moisture conservation, the husk and coir pith application as amendments had significantly influenced yam yield.

Guinea grass (var. CoGG-3) as intercrop

A field experiment was conducted to study the feasibility of growing guinea fodder grass (var.CoGG-3) as intercrop in the coconut garden by adopting soil and moisture conservation methods under coastal sandy soil. The treatments included soil moisture conservation measures viz., one layer dried coconut husk burial in the trenches and planting of grass, coconut leaves in the trenches and planting of grass and control (planting of grass with out any soil and moisture conservation measures).

Guinea grass as intercrop in coconut garden

The husk application had significantly influenced the plant height and number of tillers/clump in guinea grass during different periods of cutting. More importantly, higher green fodder

yield was obtained under husk application during each cutting (ranging from 8.0 to 8.5 t/ cutting with a total yield of 82.2 t/ha/year) and it was significantly higher than in the case of dried coconut leaf application (total yield of 49 t/ha/year and control treatment (42 t/ha/year).

Impact of intercropping systems on coconut productivity

Impact of cropping systems and soil moisture conservation measures on coconut productivity was studied. Higher coconut productivity was obtained under cropping system treatments compared to monocropping of coconut which clearly brought out the complementary role of intercropping in coconut productivity. Among the cropping systems tried, coconut + vegetable intercropping recorded higher coconut productivity (150 nuts/palm/year) which significantly differed from other cropping systems *viz.*, coconut + grass intercropping, coconut + pineapple intercropping and monocropping of coconut. Similarly, soil conservation measures (incorporation of organic sources - husk and coir pith/dried coconut leaves) had a significant impact on coconut productivity compared to control.

Evaluation of organic cultivation of coconut in coastal agro-ecosystem

The field experiment on organic cultivation practices on West Coast Tall and D x T coconut palms indicated that all the organic cultivation treatments recorded significantly higher nut and copra yield when compared to control for both the set of experiments. However, the organic cultivation treatment with vermicomposting in the basin, application of biofertilizers and cover cropping in the interspace recorded higher nut yield of 109 nuts/palm/year and copra yield of 3.53 t/ha/year in D x T hybrid, whereas a combination of vermicomposting in the basin, application of bio fertilizers and growing vegetables in the interspace recorded 84 nuts/palm/year and copra yield of 2.68 t/ha/year in West Coast Tall.

Organic cultivation of coconut

Fertilizer application through micro-irrigation in coconut under coastal sandy soil

Results of the field experiment on fertilizer application through micro- irrigation technique in coconut under coastal sandy soil has shown that the coconut yield under different treatments

viz., 50% NPK, 75% NPK and 100% NPK through fertigation were on par. The trends indicate that saving of up to 50 % of the recommended dose of chemical fertilizer can be achieved through adoption of fertigation techniques.

Profitability of intercropping tubers and vegetables in coconut gardens

Different summer crops like lady's finger, elephant foot yam, colocasia, basella and amaranth were planted in coconut garden and under open conditions under Sub - Himalayan Terai region and their growth and yield characters were recorded and economics of all the crops were worked out. The net return from one hectare of land was more in coconut with different intercrops than the monocrop except elephant foot yam as monocrop. Maximum net return (Rs. 371320/-/ha) was calculated in coconut and elephant foot yam crop combination. Maximum BC ratio of 4.16 was recorded in coconut and basella combination followed by coconut and amaranth combination. Though the net return per hectare was recorded maximum in coconut and elephant foot yam combination but the BC ratio was less due to higher cost of cultivation of elephant foot yam. Under open condition, BC ratio was maximum in these crops also. Maximum gain (581.1%) over coconut as monocrop was observed in coconut and elephant foot yam combination followed by coconut and basella combination (247.2%). Among the different intercrop combinations, intercrops had more share on net return than the main crop. Maximum percentage (82.8%) was noticed in case of elephant foot yam followed by basella (67.7%) and colocasia (64.5%).

Mixed cropping of black pepper varieties in coconut garden

Field investigations on evaluating black pepper varieties/hybrids as mixed crops in coconut garden indicated that Thevam variety had recorded significantly higher dry spike yield (1.71 kg/vine) compared to other varieties. Panniyur 1, 4 and 5, Sreekara and Panchami also recorded higher dry spike yield (0.65 to 0.86 kg/vine) compared to other varieties/hybrids. With regard to quality parameters, Panchami variety recorded higher essential oil (5.6%) and oleoresin content (12.6%) and was on par with Panniyur 4, Kottanadan, HP 1411 and OPKM. The piperine content did not differ significantly

Thevam variety of pepper grown on coconut

among the varieties/hybrids (between 2.68 to 4.97 %). The general mean yield of coconut in the plot during 2009-10 was 128.4 nuts/palm/year compared to pre-experimental yield of 97.8 nuts/palm/year indicating complimentary effect of mixed cropping black pepper on coconut yield.

Estimation of leaf critical limits for nutrients in arecanut and biomass partitioning in arecanut

The critical nutrient limit was estimated by boundary line approach. Optimum foliar concentrations for N, P, K, Ca and Mg were established as 2.70, 0.23, 1.12, 0.61 and 0.20%, respectively. Optimum micronutrient concentrations (mg kg^{-1}) were estimated at 146 for Fe, 56.5 for Mn, 2.6 for Cu, 45.8 for Zn, 39.5 for B, 432 for Al and 63 for Na. Total biomass production was significantly greater in high yielders (43.6 kg $palm^{-1}$) than in low yielders (30.8 kg $palm^{-1}$). Total standing biomass of trunk accounted for 69-74% of the total above ground biomass in arecanut palm. Dry matter partitioning to kernel was only 4-10% of the total biomass.

Nutritional disorders in arecanut

Analysis of 300 soil and leaf samples from Shimoga District has revealed that availability of phosphorus, potassium and micronutrients was higher than optimum in arecanut root zone. The analysis of about 150 soil and leaf samples collected from Kasaragod and Dakshina Kannada districts indicated nutrient imbalance both in soil and leaf samples. The results also indicated that the nutrient uptake pattern is disturbed in palms, which might be due to antagonistic nutrient interactions. The disorders might be due to imbalanced application of nutrients.

Evaluation of local accessions of black pepper at Kahikuchi

Evaluation of local accessions of Black pepper revealed that on 6^{th} year of planting, KKHP-8 performed better with a fresh weight of 4.7 kg/vine.

Cropping system model for North-East

An experiment with two models of arecanut based HDMSCS is in progress at Kahikuchi, Model-I: Arecanut + Pepper (Karimunda) + Banana (Chenichampa) + Citrus (Assam Lemon) + Clove and Model II: Arecanut + Pepper (Panniyur-1) + Banana (Chenichampa) + Citrus (Gandharaj) + Nutmeg and under different doses of fertilizers (Full, $2/3^{rd}$ and $1/3^{rd}$ of the recommended dose). Preliminary results indicate that the Model-II with $2/3^{rd}$ dose of fertilizer was better with high BC ratio of 2.60.

ORGANIC RECYCLING AND PLANT BENEFICIAL MICROBES

Vermicomposting technology using different plant substrates

A vermicomposting trial by using *Eudrilus* sp. with eight different locally available plant substrates *viz., Musa* spp, *Eichhornia crassipes*, *Mimosa* sp., *Mikania* sp., *Commelina bengalensis*, leaves of *Areca catechu,* leaves of *Cocos nucifera* and a local leguminous climber was undertaken and the recovery percentage and quality of compost were worked out. The maximum recovery percent was observed in *Eichhornia crassipes* and *Commelina bengalensis* (84-88%) within a period of 3 months.

Earthworm gut microbiome studies of coconut leaf degrading *Eudrilus* sp.

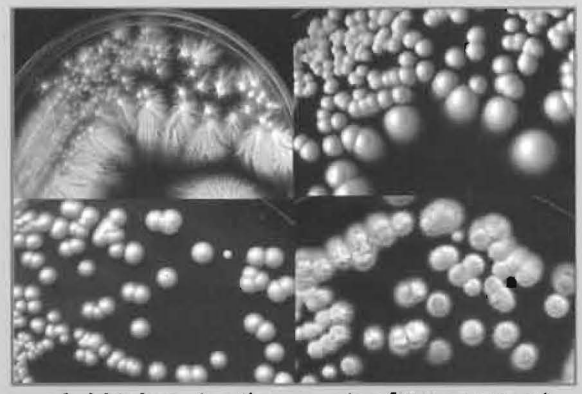
Twenty seven bacterial isolates were obtained when gut contents of *Eudrilus* sp., feeding on coconut leaves-cow dung mixture in 1:1 and 10:1 (w/w) ratios, were plated on minimal media containing 2.5% cellulose (filter paper) and 0.5% lignin (extracted from coir as well as urban wastes) as the sole carbon sources . These isolates have been purified for assessing their cellulose, ligninase and xylanase production capabilities.

Bacterial diversity studies during coconut leaf vermicomposting process

In a 16S rRNA based analysis of the bacterial diversity in different stages of coconut leaf vermicomposting process and also the gut contents of earthworm *Eudrilus* sp. feeding on this biomass, using 454 sequencer, it was observed that the Bacteroidetes and α -proteobacteria constituted 50% of the major taxonomic groups in the beginning and middle stages of the vermicomposting process. In comparison to this, the mature vermicompost had Bacteroidetes, Firmicutes, α -proteobacteria and γ-proteobacteria in equal proportions. The number of Firmicutes was observed to increase as the vermicomposting process progressed to maturity stage. The earthworm gut contents had Actinobacteria, Firmicutes and α -proteobacteria in predominance.

Identification of selected acid tolerant/acidophilic bacteria

The acid tolerant bacterial isolates from coconut rhizosphere were subjected to analysis using Biolog Microbial Identification System. They were identified as *Bacillus* subtilis (4 isolates), *Bacillus amyloliquefaciens* (3 isolates), *Bacillus pseudomycoides*



Acid tolerant actinomycetes from arecanut rhizosphere (growth at pH 2.5)

(2 isolates), *Bacillus atrophaeus* (2 isolates), *Bacillus cereus/thuringiensis* (1 isolate), *Bacillus pumilus* (1 isolate), *Bacillus mycoides* (1 isolate), *Enterobacter cloacae* (1 isolate), *Staphylococcus saprophyticus* (1 isolate) and *Bacillus* spp. (2 isolates).

The selected acid tolerant bacterial isolates from arecanut rhizosphere were identified as *Bacillus subtilis* (6 isolates), *Bacillus pumilus* (4 isolates), *Enterobacter cloacae* (2 isolates), *Bacillus cereus/thuringiensis* (2 isolates), *Bacillus pseudomycoides* (1 isolate), *Bacillus mycoides* (1 isolate), *Bacillus atrophaeus* (1 isolate), *Bacillus weihenstephanensis* (1 isolate), *Bacillus licheniformis* (1 isolate), *Serratia marcescens* (1 isolate) and *Bacillus* spp. (7 isolates).

The selected acid tolerant bacterial isolates from cocoa rhizosphere were identified as *Bacillus subtilis* (2 isolates), *Bacillus amyloliquefaciens* (1 isolate) and *Pseudomonas putida* (1 isolates).

The selected acid tolerant bacterial isolates from vanilla rhizosphere were identified as *Klebsiella oxytoca* (2 isolates), *Bacillus cereus/thuringiensis* (1 isolate), *Acinetobacter* (1 isolate), *Bacillus amyloliquefaciens* (1 isolate), *Enterobacter aerogenes* (1 isolate), *Bacillus subtilis* (1 isolate), *Klebsiella* sp. (1 isolate) and *Bacillus* spp. (3 isolates).

Cytokinin production by acid tolerant bacteria

Acidophiles were screened for cytokinin production by rapid bioassay technique based on the ability of cytokinin to stimulate greening and cotyledon expansion in etiolated cucumber cotyledons. Cytokinin fractions in bacterial extract were separated by Thin Layer Chromatography (TLC). Major cytokinins detected were kinetin and adenin. Out of 49 acid tolerant bacterial isolates from coconut rhizosphere, 27 (55%) were found to be positive for cytokinin production. *Bacillus* sp. KtPC4-32 (pH 3.5), *Bacillus* sp. KtPC5-59 (pH 3.5) and *Bacillus* sp. KtRCn4-89 (pH 4.0) which were negative at neutral pH could produce cytokinins at low pH. Out of 34 acid tolerant bacterial isolates from arecanut rhizosphere, 19 (55%) were found to be positive for cytokinin production. Four isolates produced cytokinins at acidic pH only, out of which two *Bacillus* spp., DkAA1-1 (pH 4.5) and KtRA2-67 (pH 3.5), produced both adenin and kinetin derivatives. Two acid tolerant *Bacillus* spp. from vanilla rhizosphere - TAV3-9 (pH 4.5) & KnMV3-1 (4.0) produced cytokinins only at acidic pH. None of the cocoa isolates produced cytokinins.

Gibberellic acid production by acid tolerant bacteria

GA_3 production by acidophiles was estimated by spectrophotometric method. The amount of gibberellic acid produced by the acidophiles from coconut rhizosphere ranged from 0.036 to 0.20 mg/ml in neutral pH and 0.033 to 0.18 mg/ml in acidic condition. Four coconut *Bacillus*

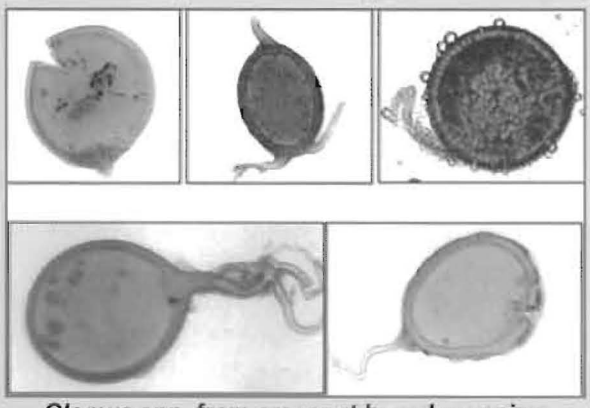
spp. KtPC5-59, KtCC1-3, KnMaC2-1 (pH3.5) and KnCC1-3 (pH 4.5) were able to produce more of GA_3 (0.08-0.18 mg/ml) at acidic pH than pH 7.0. In vanilla isolates, it ranged from 0.009 to 0.017 mg/ml at neutral pH and 0.005 to 0.008 mg/ml at acidic pH. None of the isolates from arecanut rhizosphere were able to produce GA_3.

Arbuscular mycorrhizal fungi (AMF) in coconut and arecanut-based cropping systems

Glomus species was the predominant genus in almost all of the observed samples of rhizosphere soils of coconut and arecanut, as well as their intercrops. *Glomus aggregatum* was found in rhizosphere soils of coconut, arecanut and banana collected from coconut and arecanut-based cropping systems in farmers' fields at Neerchal, Kasaragod.

Glomus fasiculatum was observed in the rhizosphere soil samples collected from coconut cropping system from Guruvayoor, Thrissur district. *Gigaspora* species were found to be associated with coconut cropping systems of Parappur, Thrissur district.

***Glomus spp.* from coconut based cropping system**



***Glomus* spp. from arecanut based cropping system**

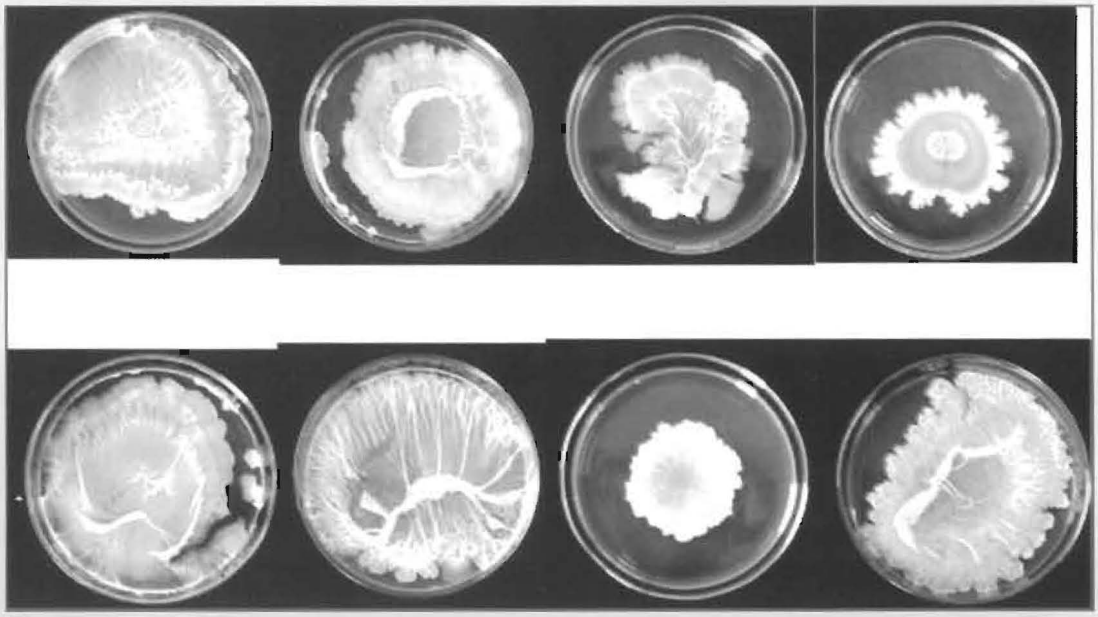
Isolation of mycorrhizae helper bacteria

AM fungal spore associated bacteria (AMB) were isolated from surface decontaminated spores. Twenty one bacterial cultures were isolated from *Gigaspora* spp. (12) and *Glomus* spp. (9). These AMB were identified by BIOLOG system based on the differential utilization of 96 carbon sources provided in the Gen III Micro Plates. The results showed the association of *Corynebacterium coyleae*, *Bacillus subtilis* and *Bacillus cereus/ thuringiensis* with *Gigaspora* spp. isolated from rhizosphere of coconut palms in the HDMSCS plot of CPCRI, Kasaragod while the *Glomus* spp. was found to be associated with *Bacillus amyloliquifaciens*.

Abiotic stress tolerance of coconut and cocoa PGPR

Experiments to study the stress responses of the selected PGPR (22 coconut and 21 cocoa isolates) indicated that *Bacillus cereus* ESB 15 isolated from the rhizosphere of coconut could tolerate a maximum temperature of 60°C and NaCl concentration of 12 % when incorporated in Trypticase Soy Agar (TSA) medium. Another *Bacillus* sp. RSB 14 from coconut rhizosphere tolerated 12% NaCl conc. *Serratia marcescens* KiSII, isolated from rhizosphere of coconut from Kidu, Karnataka could tolerate pH in the range from 4.2 to 9.0 and *P. putida* KnSF 208, a rhizospheric isolate of coconut from Kunnamkai, Kerala could tolerate pH from 5.2 to 9.0.

Five *Bacillus subtilis* isolates (CSB 8, KGEB 10, PEB 2, PEB4 and VEB 17) from cocoa rhizosphere could tolerate a maximum temperature of 60°C and were able to grow on TSA medium amended with 12% NaCl. Three *Bacillus* spp. (*B. subtilis* CSB 16, *B. subtilis* CEB 9 and *Bacillus* sp. PS2 VEB 4) from cocoa showed intrinsic resistance to 12% of NaCl in TSA. The cocoa PGPR isolates *Pseudomonas putida* KDSF 23 and *Pseudomonas* sp. KDSF 7, isolated from Kidu, Karnataka exhibited pH tolerance from 5.2 to 9.0.



PGPR isolates from coconut based cropping system

CROP PROTECTION

Disease management

Management of bud rot of coconut

Out of 136 *Phytophthora* isolates causing bud rot and fruit rot disease of coconut in disease endemic areas of southern states of India, 125 isolates were identified as *P. palmivora*. Of these, the isolate KL-Co/16 isolated from Palakkad district was found to be the most virulent isolate. Among the 125 *P. palmivora* isolates, 124 isolates were A2 mating types indicating the predominance of A2 mating type. The large scale field demonstrations conducted in disease endemic areas have further confirmed the efficacy of prophylactic treatment of palms at bi-monthly interval by pouring mancozeb solution (5 g in 300 ml water/palm) + placing 2 mancozeb sachets/palm (perforated sachets each containing 5 g mancozeb) in the innermost leaf axils or pouring phosphorous acid (Akomin) solution (0.5%) @ 300 ml/palm in the innermost leaf axil as very effective in the management of bud rot disease.

Mycological culture medium using cocoa wastes

The mycological culture medium developed using water extract of Cocoa Bean Shell (CBS) was found to be better than or on par with freshly prepared PDA medium in growth and sporulation of different groups of fungi. All the conventional media presently in use for growing and maintaining different groups of fungi are costlier than cocoa bean shell dextrose agar (CBSDA) medium. Thus, the CBSDA medium developed with the following composition was found to be ideal for growing different groups of fungi such as pathogenic, edible and biocontrol agents.

Composition of standardized CBSDA medium

CBS/ CWD	:	30 g (water extract)
Dextrose	:	15 g
Agar	:	15 g
Distilled water	:	1000 ml

The growth performance of five species of *Pleurotus viz., P. citrinopileatus, P. florida, P. gemmillarii, P. sajor caju* and *P. membranaceus* in CBSDA were much better than MEA (Hi-media). It was also interesting to observe that cocoa bean shell agar (CBSA) medium (without dextrose) also supported better growth of *Pleurotus* sp. Therefore CBS can be considered as a better raw material for media preparation.

Low-cost production technology using cocoa wastes for mass production of biocontrol agents

Selection of agricultural waste/by-product as substrate for multiplication of biocontrol agents depends on its availability in the locality, efficacy and economic feasibility. Growth and sporulation of *Trichodema harzianum* and *Metarhizium anisopliae* in cocoa sweating (CS) diluted with tap water (1:4) was found to be superior compared with that in other conventional media like potato dextrose broth, coconut water and rice water (rice soup). Thus, it has been found to be a very promising medium for mass production of these bio-agents. Growth and sporulation of *Lasiodiplodia theobromae* and *Colletotrichum gloeosporioides* and mycelial growth of *Pleurotus citrinopileatus* were also found to be significantly high in CS 1:4 compared to potato dextrose broth and potato jaggery broth. Studies on the shelf life of talc formulations of *T. harzianum* and *M. anisopliae* grown in CS 1:4 has also revealed CS 1:4 as superior to the other three culture media as the CFUs/g of talc formulations were higher in CS 1:4 throughout the period of storage (6 months).

Farmer friendly mass production technology of green muscardine fungus

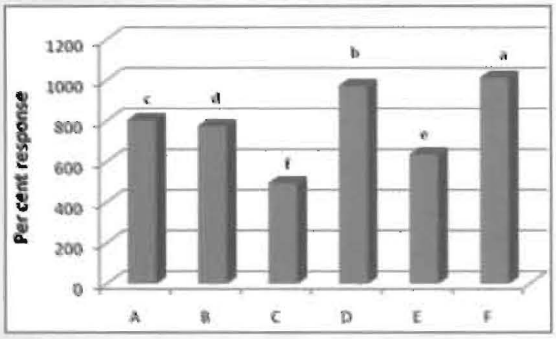
Based on the results of these studies conducted on different aspects of utilization of cocoa wastes *viz.*, cocoa sweating (CS), cocoa bean shell (CBS) and cocoa pod husk (CPH), a low cost technology has been developed for mass production of biocontrol agents. *T. harzianum* and *M. anisopliae* are initially grown in sterilized CS 1:4 medium in empty liquor bottles (375 ml capacity). The 20-day-old culture was used for inoculating unsterilized CBS, CPH and neem cake moistened with CS 1:4 for farm level mass multiplication by the farmers. The populations of both the fungi were significantly high in CBS. Though the populations in CPH and neem cake were statistically on par, the CFUs of both biocontrol agents in CPH were more than that in neem cake. This method of production of biocontrol agents is very simple and highly economical.

Pest management

Exploring the potential of pheromone and kairomone blend for coconut red weevil, *Rhynchophorus ferrugineus* (Oliver) management.

Electrophysiological antennal response of red palm weevil to volatiles was measured by the shift in amplitude (mV) in electro antennogram (EAG). There was no sexual dimorphism in weevil's antennal response to compounds. Among the host volatiles, tested ethyl propionate at 100ng caused a normalized EAG response of 248.66 per cent followed by ethyl acetate (158.83 per cent). Ethyl butyrate at 100 ng was used as reference odor in EAG assay. Across the compounds tested, the antennal response increased with age of the weevils. Dose response curves were made to the compounds that elicited physiological response. All the compounds showed significant difference among the doses tested.

Six blends of host volatiles (A-F) made at varying ratios were evaluated for electrophysiological response. Among the individual blends tested, F mix caused significantly higher antennal response followed by A and D mix. Antennal response to the CPCRI lure and Ferrolure at 100ng caused a 454 and 332 per cent response normalized EAG response over the reference compound ethyl butyrate. Two blends D and F showed synergy with CPCRI lure and ferrolure. The behavioural assay in four arm olfactometer revealed that all the blends tested were preferred by the weevils over purified air. Among the blend C mix caused maximum orientation of the weevil over the purified air followed by blend D and F.



Red palm weevil antennal response to host volatile blends

Investigations on entomophaga and entomopathogens of coconut pests

A low cost farmer-friendly technology was developed for mass production of green muscardine fungus, *Metarhizium anisopliae*, a promising entomopathogenic fungus of rhinoceros beetle of coconut. The technology was successfully demonstrated in two villages *viz*., Edava (Trivandrum district) and Thekkekara (Alappuzha district).

An outbreak of *Opisina arenosella* in Vechoor (Kottayam district) infesting about 5000 coconut palms with leaf damage to the tune of 61.4% and pest population of 304/100 leaflets could be brought down to negligible levels within a period of 18 months by the innundative release of larval parasitoids *viz*., *Goniozus nephantidis* and *Bracon brevicornis* through farmer-participatory mode.

Mite management trial using talc formulation of acaropathogenic fungus, *Hirsutella thompsonii* @ 20g/litre/palm (160 x 10^6 cfu) with a frequency of 3 sprays per year could result in 63-81% reduction in eriophyid mite population over control. The field establishment of *H. thompsonii* could be assessed through successful re-isolation of the fungus from nut samples collected from treated palms.

Median lethal concentration (LC_{50}) of *Heterorhabditis bacteriophora* was found to be higher (614 IJ) than that of *Heterorhabditis indicus* (356 IJ) for the same exposure time of 96 h indicating higher toxicity of *H. indicus* against grubs of red palm weevil. Synergistic interaction of *Steinernema carpocapsae* (5000 IJ) as well as *Steinernema abbasi* (5000 IJ) with imidacloprid (0.002%) against coconut white grub was observed accelerating the kill (> 85%) within a period of 48 h in a soil column based bioassay.

Refinement of IPM for major pests of coconut

Assessment of trap density using the refined PVC traps with one trap in 1 ha to 5 ha area indicated the highest catch of beetles (22 beetles / month) in traps placed @ 1 trap / 5 ha area with predominance of female beetles (66%) in all collections.

Significant reduction in leaf damage by rhinoceros beetle was observed in palms with leaf axil filling of 6.0 g Chlory dust along with 250 g sand. Evaluation of Chlorantraniliprole 0.25 g (Ferterra) induced 90% mortality of red palm weevil grubs in coconut petiole based bioassay.

A significant recovery (60.0-79.1%) of red palm weevil infested palms was observed in palms treated with imidacloprid (0.02%), spinosad (0.013%), indoxacarb (0.04%), carbaryl (1%) and a combination pesticide of chorpyriphos and cypermethrin (0.1%). Highest recovery (79.1%) was registered in imidacloprid (0.02%) treated palms.

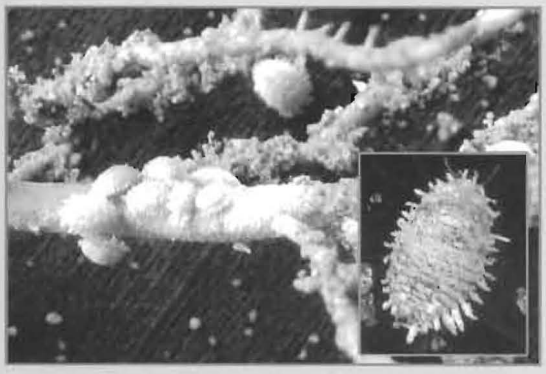
Surveillance on possible invasive and emerging pests of coconut

An outbreak of coffee spotted grasshopper, *Aularches miliaris* (Acrididae: Orthoptera) was recorded in May 2010 at Erattayar Panchayat, Idukki district. The insect was found predominantly feeding on *Erythrina indica* and weeds such as *Clerodendron* sp., *Macaranga indica, Abutilon indicum* etc with very negligible incidence in coconut and arecanut.

Occurrence of Asian grey weevil, *Myllocerus undatus* Marshall (Curculionidae : Coleoptera) was reported for the first time in Kerala, damaging 5-10% leaf lamina of un-split leaves of coconut seedlings in nurseries with typical notching symptom.

Incidence of buff coconut mealy bug, *Nipaecoccus nipae* (Maskell) (Pseudococcidae: Hemiptera) on tender roots of coconut seedlings was observed. This mealy bug species was not located on foliage or other arboreal parts of the palm.

Palm aphid encrustation on spindle leaf



Mealybug colony on feeder roots

Aggregation of palm aphid, *Cerataphis brasiliensis* (Hempel) (Aphididae: Hemiptera) was noticed on unfurled spindle leaf of Kalparaksha variety of coconut and was totally absent on other coconut varieties in the farm indicating a variety-induced emergence of the pest.

Asian grey weevil infesting on coconut seedling

Pest surveillance in Lakshadweep Islands

Survey undertaken in three Lakshadweep Islands *viz.*, Minicoy, Kavaratti and Kalpeni island ecosystem revealed high mite infestation of 57.5% in Kavaratti, a moderate incidence of 23.2% in Kalpeni and a low infestation of 17.9% in Minicoy Island. Rat damage was found to be a recurring menace in all the islands. Rhinoceros beetle damage is at a low level in all the three islands. The lethal pest of coconut *viz.*, Red Palm Weevil is not recorded in any of these islands surveyed. Minor pests like scale insects, spiralling whitefly, plant hopper and lace bugs could be recorded sporadically in the Islands. The invasive pest, *Brontispa longissima* was not recorded from any of the islands including the uninhabited islet surveyed. Since the invasive pest had reportedly reached Maldives, Agricultural Officials of all the three islands were appraised of the need for constant monitoring of the pest as Minicoy Island is in close proximity to Maldives.

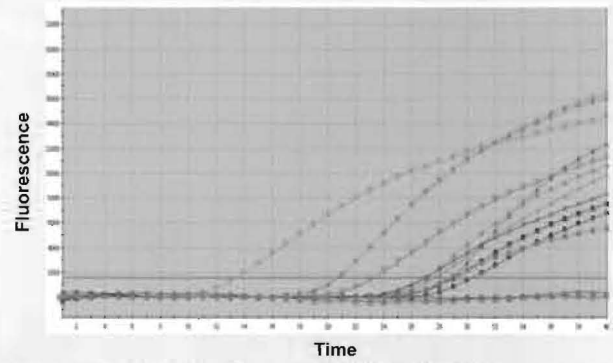
Digestive proteinases of major insect pests of coconut and their interaction with inhibitors.

Studies on luminal proteinases of *Rhynchophorus ferrugineus* revealed the presence of two more endodpeptidases *viz.*, elastase-like chymotrypsin (SAAL*p*NA-ase activity) and

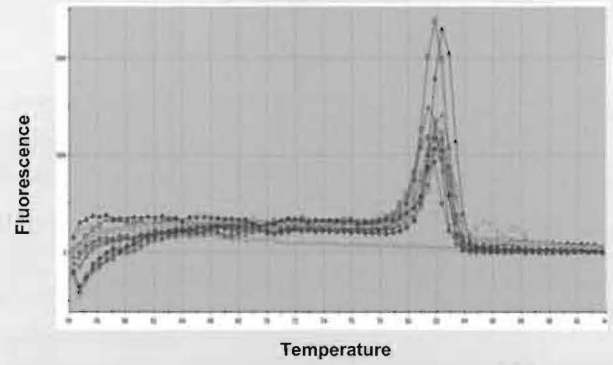
chymotrypsin (BT*p*NA-ase activity) in all stages of larval development. Highest activity of these endopeptidases coincided with the active feeding stage of the insect. Elastase-like chymotrypsin in *R. ferrugineus* was found to be the highest in 50 mM Tris-HCl buffer (pH 8.0) with incubation for 25 min at 40°C. Classical serine proteinase inhibitors *viz.*, aprotinin, soybean trypsin inhibitor and phenyl methyl suphonyl fluoride had a marginal reduction (31-34%) in elastase-like chymotrypsin activity. *In vivo* bioassay of 100µm aprotinin on leaf disc method using *Opisina arenosella* larvae indicated a weight loss of 25.1% due to incorporation of serine protease inhibitor in a period of 96 h.

Molecular detection and characterization of phytoplasma of coconut root (wilt) disease from insect vectors

DNA isolation from insect vectors for molecular detection studies has been standardized. One of the key lysosomal enzymes *viz.*, β-glucosidase activity varied significantly between field collected *P. moesta,* freshly emerged *P. moesta* and those insects that had completed acquisition, access and incubation period of more than 30 days. β-glucosidase activity in *P. moesta* was found lower than acid phosphatase and β-galactosidase activities studied.



Real time PCR amplication plot of DNA from different samples using the phytoplasma specific primer



Melt curve of different samples showing the peak at the same position

PHYSIOLOGY & BIOCHEMISTRY

Genotype dependent proteases and oxidative isozyme response of coconut under elevated CO_2 and temperature

Quantitative assay of Total Protein/HSPFs in five cultivars has shown significant differences among treatments and cultivars. Oxidative isozyme profile for SOD (Superoxide dismutase) and PPO (Poly phenol oxidase) in WCT and COD exposed to elevated CO_2 and temperature has been elucidated. Out of the 13 isoforms of SOD, five were Cu/Zn-SODs, four Mn-SODs, two Fe-SODs and two unknown isoforms of very high molecular weight. Under sequential heat treatments, nine of these isoforms lost their activity by 80° C and only 4 isoforms (two each for Cu/Zn-SOD and Mn-SOD) were stable up to 80°C and at 100°C, only two existing isoforms of Cu/Zn-SOD were stable and two new isoforms of Cu/Zn-SODs were also formed afresh.

Climate change impact studies in plantation crops

Net photosynthetic rate was more under elevated CO_2 in Open Top Chambers and increase was significant in seedlings supplied with higher doses of vermicompost in coconut, cocoa and arecanut. Notwithstanding varietal differences, the average PS II efficiency, Fm/F_0 and Fv/F_0 in coconut varieties increased linearly with nutrient application at 700 ppm. PSII efficiency was slightly more in cocoa cultivars under elevated CO_2 and temperature [T+2°C], whereas it declined in arecanut.

POST HARVEST TECHNOLOGY

Value chain in coconut

The technology for production of vinegar from coconut water was further refined. The mother culture was prepared from fresh toddy and alcoholic ferment from coconut water. When the mother culture attained an acidity of 4%, the alcoholic ferment was added and kept for further acetification. Once the acidity of the mixture attained 4- 5.5%, vinegar was collected and pasteurized, filtered through filter sand and activated carbon to remove the colour.

Cabbage intercropping under coconut garden

As part of the technological interventions at field level, intercropping of elephant foot yam and cool season crops viz. cabbage and cauliflower in the interspaces of coconut garden were carried out in farmers, field under ten clusters. The average corm yield ranged from 16 to 22.4 t from one hectare of coconut garden. Intercropping of cauliflower and cabbage in coconut garden showed that cauliflower and cabbage can be successfully cultivated in areas traditionally believed to be not suitable for cool season crops. By adopting various technologies like basin management, intercropping, pest and disease management, integrated nutrient management and organic recycling in the framers field could bring an impact of 14 % increase in coconut yield.

Shell-fired coconut chips dryer

A shell-fired coconut chips dryer of 75 nuts capacity has been developed. Initial trials indicate that it takes about 8 hours to dry the chips. This dryer has a unique burner with fuel tray. Once fuel is charged heat is produced for about two and half hours. No electrical energy is used in this dryer.

Coconut and arecanut palm climbing device

One of the difficulties being faced by coconut and arecanut farmers in undertaking timely harvesting and plant protection measures is the inherent difficulty in palm climbing and inadequate availability of skilled manpower especially climbers. Towards addressing this problem, a simple coconut and arecanut palm climbing device has been developed. It consists of a pair of 'U' shaped frames made up of mild steel square pipes. The frames are laminated with vulcanized rubber to get good grip with the tree trunk and a foot rest is provided at one side of the each frame near to the open end. Provision is given on the foot rests for the user to fix a pair of shoes of his size and choice. The user can fix the climbing device to his feet by wearing the shoes attached to the device and can move up and down the coconut and arecanut tree as easily as he climbs a vertical ladder. A safety gadget is also provided.

A woman trainee climbing coconut palm with the help of climbing device

SOCIAL SCIENCES

Training programmes and assessment of their effectiveness

A model training course on 'Coconut based integrated farming for higher income and employment' sponsored by Directorate of Extension, Ministry of Agriculture, New Delhi was organised at CPCRI, Kasaragod during 1-8 December 2010. Extension personnel representing six states participated in the model training course. Another training programme on 'Advances in arecanut and cocoa production technology' was organized at Vittal during 22-28 November 2010. A special training programme on Post Harvest Processing in Plantation Crops was organized for 10 officials of NABARD during 31 January to 3 February 2011. At Kayamkulam, a training programme on root (wilt) disease of coconut was conducted for 8 officials of the Department of Horticulture, Karnataka.

Trainees of the Model Training Course along with training faculty

A residential training programme on 'Value addition in coconut' sponsored by the High Value Agriculture Development Agency, Andaman and Nicobar Islands Administration was conducted at CPCRI Kasaragod during 15-23 November 2010 in which 29 tribal farmers from various islands of A&N attended. Training programme on processing methods of virgin coconut oil was conducted as part of sale of technology to a group of six farmers from Shimoga, Karnataka. Eight special training programmes on 'Preparation of coconut chips' were also organized at Kasaragod in which a total of 103 entrepreneurs from various regions participated. At Vittal, two training programmmes on cocoa production technology sponsored by Directorate of Cashewnut and Cocoa Development (DCCD), Cochin was organized during 27-28 August 2010 and 23-24 September 2010. Farmers from cocoa growing areas in Karnataka and Tamil Nadu states participated. At Kayamkulam, 27 one-day training programmes and skill demonstrations were imparted for over a thousand farmers under various programmes like ATMA, SHM, NHM and cluster programme.

A Study to assess the effectiveness of training programmes by CPCRI was conducted among the 40 randomly selected farmer participants of the on-campus trainings conducted at CPCRI, Regional Station, Kayamkulam under ATMA and Coconut cluster programmes during 2007- 2009. The trend in adoption of technologies showed higher adoption level in the case of organic manure and green manure application along with scientific basin opening (> 80%) indicating the receptivity of coconut farmers to refining their traditional practices based on scientific knowledge. The major training needs identified were self doable practices, tools or equipments for operations by small and marginal farmers, marketing techniques and income improving technologies, vermicomposting techniques, rat control, community nursery for quality seedling production, organic cultivation of coconut and machineries for coconut climbing.

New initiatives in cyber extension

Cyber extension programmes of the Institute were further strengthened during the year with the addition of mobile video conferencing unit. The mobile video conferencing unit is being utilised for facilitating the Research-Extension-Farmer interface through Wi-Max 2 Mbps connectivity, secured in collaboration with BSNL. This facility was inaugurated by Prof. K.V. Thomas, Hon'ble Minister of State for Agriculture on 25-01-2011 during the inaugural function of International Conference on Coconut Biodiversity for Prosperity. Since then, two interface programmes were conducted involving scientists at CPCRI Kasaragod and farmers and extension personnel at Kannur and Kanhangad.

Agri-Fair 2010

A mega exhibition christened 'Agri-Fair 2010' was organized at CPCRI, Kasaragod during 25-28 October 2010 in which over 25 research, extension and developmental agencies participated. Several services for farmers like distribution of planting materials, information on various technologies for production, protection and processing and value-addition, and credit facilities extended by banking institutions were arranged under one roof. More than 18, 000 farmers, students and general public visited the exhibition.

Visitors at the Agri Fair 2010 during the International Conference

Field level utilisation of micro-irrigation technology in North Kerala - An innovation system analysis

Analysis of data collected from farmers revealed that the extent of discontinuance of drip irrigation technology among the farmers was 75 per cent in Kasaragod District and 79 per cent in Kannur District. Even among the farmers who continued to adopt the drip irrigation technology, the extent of adoption of recommended practices for drip irrigation technology was low which has resulted in low irrigation efficiency as reflected by the indicators of technical performance of the irrigation system. Emitter clogging was reported as one of the most important problems experienced by the farmers, resulting in discontinuance of the drip irrigation technology.

Farmer participatory action research programme (FPARP)

Water harvesting storage tank inaugurated under FPARP project at Vallikadavu

Water well recharging unit inaugurated under FPARP project at Meeyapadavu

Storage tanks for run-off collection as a low cost water harvesting intervention constructed at Vallikadavu in Balal gramapanchayat and at Neerchal in Badiadka grama panchayat of Kasaragod District under the Farmer Participatory Action Research Programme (FPARP) sponsored by the Ministry of water Resources were commissioned. Besides, a roof water harvesting tank of 20000 lit. capacity and a recharging well unit constructed at Meeyapadavu village of Kasaragod District were also inaugurated. An awareness-cum-training programme for farmers on 'soil and water conservation and water harvesting in coconut gardens' was also conducted at Meeyapadavu, Meenja grama panchayat of Kasaragod District. Case studies conducted under this programme in farmers' field revealed the efficacy of soil and water conservation and low

cost water harvest technologies for water saving/water use efficiency, yield enhancement in crops and enhancing cropping intensity in farmers' gardens.

Livelihood options of rural women in a coconut based system

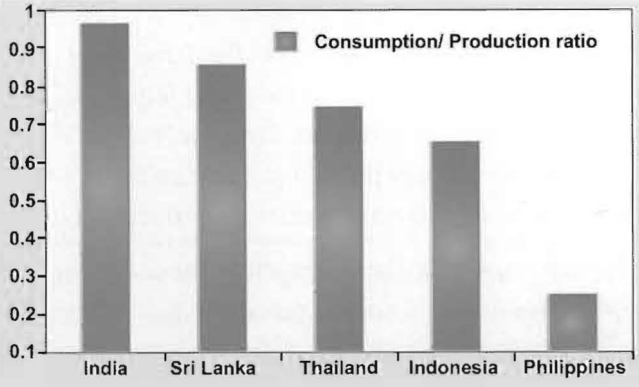
Gender analysis on the role of women in coconut cultivation indicated high level of knowledge and involvement in terms of self labour, assisting and supervising in areas like seedling management, plant protection of seedlings, sale/marketing of nuts, copra or oil making and preparation of other products and selection and planting of intercrops. The areas of livelihood options preferred by rural women were farm level coconut value addition, mushroom cultivation and low cost spawn production, planting and management of dwarf coconut varieties and stingless bee units.

Community level adoption of green muscardine fungus in RB-IPM

A pilot programme for bridging the gap in the supply of green muscardine fungus (GMF), an effective bio agent used in treating breeding sites of rhinoceros beetle as an IPM component, was implemented in Thekkekara, Devikulangara and Edava panchayaths in an area of approximately 1500 ha. Four women groups were trained in the low cost farm level multiplication of the bio agent (technology developed by CPCRI) and breeding sites were treated with GMF by women self help groups. The preliminary effect of the adoption as perceived by the women farmers were recovery of infected adult beetles and grubs and reduction or absence of grubs in the breeding sites like cow dung pits or compost units. The pilot scale implementation indicated reduction in cost and time gap of technology adoption and downsizing of technology to be women/community friendly.

Policy oriented research on palms and cocoa

While analyzing the export orientation of coconut growing countries, using the Consumption-Production Ratio method, it was observed that the major producers of coconut are distinct in their behaviour. While the Philippines consumes only around one-fourth of its total production, that in Indonesia is three-fourth, and interestingly India has the distinction of consuming almost all of its domestic



Production consumption pattern among major coconut producing countries

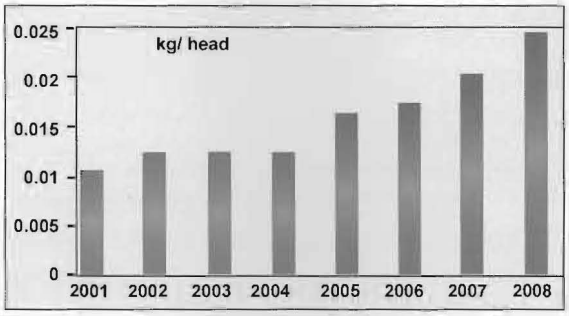
production. Sri Lanka and Thailand also report consumption of major share of their production. However, the prospects of a higher export of coconut oil as of now may not materialize as the price wedge between Indian coconut oil and the international prices is huge. More over, as the analysis indicates, our Consumption-Production Ratio is much higher in comparison with other major exporters. While Indonesia and Philippines set apart 50% of production for export, consequently controlling the international price of coconut oil.

Analysis of the impact of coconut oil import on domestic prices revealed that the imports do not have much influence on domestic price fluctuations. Furthermore, the import intensity (import as a percentage of total production) of coconut oil was hovering around five percent, which is not a sufficient quantum to have any effect on domestic price fluctuations. Thus, debatably the analysis indicates that the price fluctuations in the case of coconut and coconut oil are very much associated with the trade movements and supply of other edible oils. Except in Kerala, coconut oil is mainly used for toiletry purposes and for soap manufacturing. With the increase in coconut prices the general soap and detergent markets always tend to shift away from coconut oil to other substitutes, underscoring the need to promote coconut as a food and beverage crop.

Marketing, price analysis and international trade in plantation crops

The per capita consumption of cocoa in the country was estimated using Production-Trade balance and Stock-Grind Ratio of cocoa beans. Although the per capita consumption in India (0.021 kg/head) is meager in comparison with major cocoa consumers, the consumption has been continuously increasing over the last 10 years, reflecting a bright prospect for the cocoa sector. The profit margin per kilogram of cocoa dry bean has been estimated to be Rs 75. Taking into consideration the present day food consumption patterns and growth of confectionary industry in India at around 15 %, the demand for cocoa is likely to increase in coming years. The procurement strategy of the major buyers has shifted to the domestic sphere where they can save on transaction costs. Nevertheless, the domestic cocoa prices are highly integrated with the international prices and the price instability is also very high. Therefore, any supply shock in the International arena may influence the domestic prices as well.

In response to the increase in domestic consumption of cocoa, the international chocolate companies are increasingly procuring cocoa from the domestic markets. Studies on spatial price integration among the regional cocoa markets in Kerala and also its integration with world cocoa market price indicated that there is a co-movement of prices and thus they are integrated markets in nature. Consequently, the price fluctuations in the world market will be transmitted to the domestic market and can affect the domestic price.



Per capita consumption of cocoa in India

The study on domestic tender coconut marketing chain revealed that the producers' share in consumer rupee in the case of tender coconut in Kasaragod district was 45 percent. The market margin realized by middlemen was estimated at Rs.1.68 per nut and the corresponding market margin for the vendor was found to be Rs 2.73 per nut.

The cost of production of one kilogram of arecanut in a well-maintained garden was worked out to be Rs 76.5. The economic life span of the palm was taken as 35 years and average annual production as 2750 kg/ha.

Refinement of experimentation techniques

Spatial modelling technique, which has only a simple assumption of the existence of a smooth spatial function, is used to estimate/eliminate the location effect in field experiment with coconut. Two years average yield data of 560 coconut palms from a block with 9 treatments was used for the study. The study showed a significant reduction in the standard errors for comparing treatment means by using spatial technique. Further, a new approach to the estimation of location parameter, which is robust even if the underlying distribution is non-symmetric, was also proposed. The leave-one-out estimate of the kernel density function was used as the weight function for computing the location parameter.

KRISHI VIGYAN KENDRAS

KRISHI VIGYAN KENDRA, KASARAGOD

Training programmes

Training for farmers on goat rearing under SGSY programme under Manjeshwara Block Panchayath

Krishi Vigyan Kendra, Kasaragod organised 85 training programmes during the year with the participation of 1891 trainees. This includes the skill development training programmes under SGSY sponsored by Manjeshwar Block Panchayath and trainings sponsored by NABARD and ATMA.

Front Line Demonstrations

Farmer participatory management of bud rot disease in coconut: Under this programme, 2 perforated sachets containing Mancozeb was placed during onset of monsoon and after one month in the top leaf axil (spindle leaf). No incidence of bud rot disease was observed in the treated palms in any of the 15 households of Bela village, where the programme was implemented.

Management of fruit flies of mango using methyl eugenol traps: The control of fruit flies of mango using Methyl Eugenol traps was carried out in 100 homesteads of Mogral Puthur, Madhur and Muliyar Panchayats. A reduction in pest incidence from 50% to 9% was observed with an average trapping of 120 fruit flies per week per trap.

On Farm Trials

Control of foot rot disease of black pepper using bio control agents: In this trial, no incidence of disease was noticed in pepper vines treated with pre and post monsoon spray with 1% BM and *Trichoderma harzianum* multiplied in neem cake. However, slight disease incidence (5%) was observed in vines treated with Pre and post monsoon spray with 0.3% Potassium phosphonate with soil application of *Pseudomonas fluorescence* multiplied in FYM.

Effect of Cassava based bio-pesticide for the management of pseudo-stem weevil: The control of pseudo-stem weevil in banana was tested with technology options like application of cassava based bio-pesticide at fortnightly intervals, application of Chlorpyrifos 2.5 ml/l at an interval of one month from the fourth month of planting and using pseudo-stem traps smeared with *Beuvaria bassiana*. Application of chlorpyrifos was found to be superior with only 3% incidence followed by cassava based bio-pesticide with 5% incidence as against 26% incidence in farmers practice of placing bar soap in leaf axils. The cassava based biopesticide was released for commercial applications by CTCRI, Thiruvananthapuram.

Extension activities/special events

KVK, Kasaragod carried out a total of 1181 extension activities. The e-linkage facility was established at KVK, Kasaragod the national level inauguration of which was done by Hon. Minister for Agriculture Shri. Sharad Pawar on 21-4-2010 at ICAR, New Delhi. Hon'ble Minister of State for Agriculture, Food and Public Distribution, Prof. K. V. Thomas visited KVK on 2.7.2010. The committee on Private Members Bills and Resolutions of XIIth Kerala State Legislative Assembly visited the KVK on 11th June 2010. The 15th SAC Meeting was held on 28.07.2010. KVK celebrated "Karshaka Swanika" on Chingam 1st and Technology Week "Akshaya-2010" from 14-18 December 2010. During the year, the "Plant Health Clinic" funded by the Kerala State Horticulture Mission and the innovative entrepreneurship development facility "Agricultural Technology Incubation Centre" were inaugurated by Shri. Mullakkara Ratnakaran, Hon. Minister of Agriculture, govt. of Kerala at KVK, Kasaragod.

Training on seasonal fruit processing at KVK

Shri Mullakkara Rathnakaran, Minister for Agriculture, Kerala inaugurating the 'Plant Health Clinic' at the KVK, Kasaragod

KVK, ALLEPPEY

Training programmes

The Krishi Vigyan Kendra, Alleppey organized 116 training programmes during the year, of which 52 were on campus and 31 off-campus. Out of the total participants 36.1% were men and 63.9% were women participants.

Trainings	No. of batches	Participants		
		Men	Women	Total
On campus	52	409	614	1023
Off-campus	31	292	495	787
Sponsored	29	307	625	932
Vocational	4	11	70	81
Total	**116**	**1019**	**1804**	**2823**

Front Line Demonstrations (FLDs)

Frontline demonstrations on six different technologies *viz.*, micro nutrient management in paddy, improving income from homestead dairy through promoting crossbred male calves, use of automatic vaccinator against duck diseases, cultivation of white elm mushroom in paddy straw, use of copra drier for quality copra production and eco-friendly pest management in paddy have been completed. Besides, three technology demonstrations are in final phase and thirteen technology demonstrations had been initiated during the period.

On Farm Testing (OFTs)

On farm assessment was done on four technologies to find their suitability to local needs. The technologies tested were milking device for a mini dairy unit, banana special from IIHR, use of cartap hydrochloride in paddy nursery and management of rice stem borer. Assessment of sixteen different technologies has also been initiated.

INTERNATIONAL CONFERENCE ON COCONUT BIODIVERSITY FOR PROSPERITY

International Conference on "Coconut Biodiversity for Prosperity" was organized at the Institute from 25-28 October, 2010, with the participation of over 250 delegates from India and abroad including the delegates from eleven countries *viz.*, United Kingdom, USA, Australia, France, Mexico, Brazil, Indonesia, Philippines, Sri Lanka, Cote de" Ivoire and Nigeria in association with Indian Society for Plantation Crops, Bioversity International. The conference deliberated the present status of research and development on coconut, particularly biodiversity conservation and utilization, and formulated the strategies and the research priorities for the future.

Prof. K.V. Thomas, Hon'ble Union Minister of State for Agriculture, Consumer Affairs, Food & Public Distribution, Govt. of India has inaugurated the conference 25th October, 2010. He has highlighted the problems, opportunities and challenges in the coconut sector and suggested that the efforts on product diversification, unravelling the nutraceutical and health benefits of coconut and adoption of farming system models are essential for providing better opportunity for improved income from coconut. Dr. H.P. Singh, Deputy Director General (Hort.), ICAR, while welcoming the gathering has outlining the background of organizing the international conference in the light of problems being faced by coconut community, the global research needs on coconut development and the opportunities available.

Dr. S. Ayyappan, Secretary, DARE & Director General, ICAR delivered the keynote address highlighting the role of coconut farming in the lives of people in the coconut growing states and congratulated the scientists for the research accomplishments over the past 95 years.

Prof. K.V. Thomas inaugurating the International Coconut Conference, Dr. S. Ayyappan, DG, ICAR, Dr. H.P. Singh, DDG (H), ICAR, Shri P. Karunakaran, M.P., Shri C.T. Ahmed Ali, M.L.A., Dr. George V. Thomas, Director, CPCRI, Dr. Stephan Weise, Bioversity International and Dr. Romulo N. Arancon, Jr. APCC are the dignitaries on the dias

Dr. S. Ayyappan, DG, ICAR delivering Keynote Address during the Conference

Shri P. Karunakaran, Hon'ble Member of Parliament from Kasaragod and Shri C.T. Ahmed Ali, Member of Legislative Assembly from Kasaragod also participated in the inaugural function, offered their felicitations.

The conference had 11 technical sessions on global and national scenario of coconut biodiversity, conservation and utilization of genetic resources, biotechnological tools bioinformatics applications, resource management, climate change adaptation and mitigation, integrated pest and disease management, post harvest technology and value addition, technology transfer and Interface with farmers.

Four workshop sessions were organised in coconut and health, organic farming in coconut, coconut wilt and lethal yellowing and somatic embryogenesis and micropropagation. Three plenary lectures were delivered by eminent personalities: on 'Dynamics and co-kinetics of coconut research and development in India' by Dr. H.P. Singh, DDG (Horticulture), ICAR, 'Promoting multipurpose uses and competitiveness of coconut sector' by Dr. P. Rethinam formerly Executive Director, Asia and Pacific Coconut Community and 'Coconut Oil as an ideal fat next to mother's milk' by Dr. B.M. Hegde, Formerly Vice Chancellor, Manipal Academy of Higher Education, Manipal, India.

Kasaragod Declaration

Considering the challenges faced by the coconut community as deliberated during the conference, the conference adopted a declaration known as Kasaragod Declaration, which was unanimously endorsed by the congregation of global researchers from 11 countries across the coconut world assembled at Kasaragod. The declaration highlighted the need for promoting coconut as food crop for nutrition, health care and environmental services rather than just an oil crop and enumerated the required global initiatives for a better understanding of structural and functional genomics, long-term conservation through cryopreservation of genetic resources, unfolding of more nutritional and health benefits and perspective to support the farming community and also the consumers.