अनुसंधान विशेषताएँ

RESEARCH HIGHLIGHTS

2007-08

केंद्रीय रोपण फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)
कासरगोड़, केरल - 671 124

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
KASARAGOD - 671 124, KERALA, INDIA

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Research Highlights 2007-08

PREFACE

The highlights of achievements and progress made by the institute on research and transfer of technology programmes in the mandate crops-coconut, arecanut and cocoa and the glimpses of the results of AICRP (Palms) during the year 2007-08 are summarised in this publication.

Four high yielding varieties of coconut Kalpa Prathiba, Kalpa Dhenu, Kalpa-Mitra and Kalpa Raksha, proposed by CPCRI, were recommended for release during the Biennial Workshop on AICRP (Palms) held at ANGRAU, Hyderabad during 27-29 November, 2007. Five varieties/hybrids from the AICRP Centres were also recommended for release in the Workshop. Clonal fidelity of arecanut tissue culture plantlets derived through direct somatic embryogenesis from inflorescence explants of yellow leaf disease (YLD) resistant palms could be established. Molecular characterization of 40 fluorescent pseudomonads isolated from coconut leaf vermicompost by RAPD analysis revealed phylogenetic relationship among the isolates. Potassium solubilizing bacteria could be isolated from the rhizosphere of coconut using potassium aluminosilicate as the insoluble source of potassium.

Banana variety, Grand Naine was found to be a suitable intercrop for coconut gardens in littoral sandy soil with coir pith and husk amendments. Coconut based mixed farming system comprising of fodder grass, pepper, banana, dairy and poultry provided a net return of Rs.1,29,070/- per ha during the year. Studies in arecanut – cocoa cropping system revealed carbon sequestration of 2.02-3.89 t/ha in cocoa and 5.14–10.94 t/ha in arecanut annually. Using coconut simulation model, yields were simulated for 13 agro-climatic zones represented by 16 centres and yield projections were made upto 2080 scenarios.

A large scale field trial conducted in six coconut gardens in Kasaragod district revealed the efficacy of Indofil M-45 sachets for prophylactic control of bud rot disease of coconut. In Post Harvest Technology, coconut testa remover and grating machines have been designed and fabricated for utilization in production of virgin coconut oil and other value added products. Cyber Extension Project was inaugurated by Dr. H.P. Singh, DDG (Hort.) and it facilitated greater interaction among the scientists, extension personnel and farmers.

I take this opportunity to thank all those involved in delivering significant contributions for the advancement of science and for the benefit of the farming community.

(Dr. George V. Thomas)
Director

February, 2008

प्रस्तावना

इस संस्थान की मुख्य फसलें जैसे नारियल, सुपारी एवं कोको के अनुसंधान एवं प्रौद्योगिकी हस्तांतरण कार्यक्रमों पर इस संस्थान द्वारा प्राप्त की गई प्रगति एवं उपलब्धियाँ तथा वर्ष 2007-2008 की अवधि में अखिल भारतीय समन्वित ताड़ अनुसंधान परियोजना के परिणामों को सारगर्भित रूप में इस प्रकाशन में प्रस्तुत किया गया है।

विमोचन हेतु कें रो फ अ सं द्वारा रखे गए नारियल की चार उच्च उपज प्रदत्त प्रजातियाँ जैसे कल्प प्रतिभा, कल्प धेनु, कल्प मित्रा और कल्प रक्षा का प्रस्ताव अंगराउ, हैदराबाद में 27-29 नवंबर 2007 तक आयोजित अखिल भारतीय समन्वित ताड़ अनुसंधान परियोजना की द्विवार्षिक बैठक में अनुमोदन किया गया है। इस कार्यशाला में अखिल भारतीय समन्वित ताड़ अनुसंधान परियोजना के केंद्रों से पाँच प्रजातियों/संकरों के विमोचन के लिए सिफारिश किया गया। पीला पत्ता रोग प्रतिरोध ताड़ के पुष्पक्रम कर्तोतक से सीधा दैहिक भ्रूणोद्भाव द्वारा सुपारी ऊत संवर्द्धन पादप का क्लोनीय वास निकाला गया और स्थापित किया जा सकता है। आर.ए.पी.डी. द्वारा नारियल पत्तों के वर्मीकंपोस्ट से एकलित 40 फ्लूरोसेंट स्यूडोमोनस का आण्विक गुणावगुणन से यह देखा गया कि एकलन के बीच जातिवृत्तीय संबंधत्व है पोटाशियम के अविलेय स्रोत के रूप में पोटाशियम अलुमिनोसिलिकेट का उपयोग कर नारियल के मूल परिवेषी से पोटाशियम विलेय जीवाणु का एकलन किया जा सकता है।

बलुआर रेतीली मिट्टी में कयर गूथा और छिलके के प्रयोग के नारियल बाग के लिए अंतर फसल के रूप में केला प्रजाति, ग्रांड नाइन उचित पाया गया। चारा घास, काली मिर्च, केला, दुग्धपालन, मुर्गीपालन सहित नारियल आधारित मिश्रित सस्यन पद्धति से प्रति हेक्टर प्रति वर्ष कुल आय 1,29,070/- रुपए प्रति वर्ष प्राप्त किया गया। सुपारी - कोको सम्मिलित फसलन पद्धति पर किए गए अध्ययन से कोको में कार्बन प्रच्छादन 2.02 - 3.89 टन/ हेक्टर और प्रति वर्ष सुपारी में 5.14-10.94 टन/हेक्टर पाया गया। अनुकरण मॉडल का उपयोग कर 16 केंद्रों द्वारा प्रतिनिधित्व किए गए 13 सस्य जलवायु क्षेत्रों के लिए उपज अनुकरण किया गया और उपज नियंत्रण 2080 परिदृश्य तक किया गया था।

कासरगोड़ जिले में छह नारियल बागों में बड़े पैमाने पर प्रक्षेत्र परीक्षण आयोजित किया गया और नारियल के कली सड़न के रोग-निरोधी नियंत्रण के लिए इंडोफिल एम 45 की क्षमता देखी गयी। कटाई उपरात प्रौद्योगिकी में नारियल बीज चोल निकालने का यंत्र तथा कद्दूकस मशीन का रुपांकन किया गया और वार्जिन नारियल तेल तथा अन्य मूल्य वार्द्धित उपज के उत्पादन में उपयोग हेतु निर्माण किया गया। साइबर विस्तार परियोजना का उद्घाटन डॉ. एच.पी. सिंह, उप महानिदेशक, बागवानी द्वारा किया गया और वैज्ञानिक, विस्तार कार्मिकों और कृषकों के बीच आपसी संपर्क बढ़ाने में सुविधा प्रदान की गई।

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

जॉर्ज वी. थॉमस

फ़रवरी, 2008

(जॉर्ज वी थॉमम)
निदेशक

CROP IMPROVEMENT

High yielding coconut varieties

Four high yielding varieties of coconut proposed by CPCRI were recommended for release in the XIV Biennial Workshop of AICRP on Palms held at Hyderabad during 27-29 November, 2007.

- **Kalpa Prathiba (Fig. 1) :** The variety is a regular bearer, relatively tolerant to drought and suited for west coast region of the country and peninsular India. The fruits are large, round in shape and predominantly green in colour. The average annual yield of this variety is 15874 nuts / ha, 4.07 tons copra / ha and 2.73 tons oil / ha. This variety has the potential to produce, on an average, 23275 nuts, 5.97 tons of copra and 4.01 tons of oil per hectare. The quality of tender nut water is good with 5.5 g total sugars / 100ml, 1.1 mg free amino acids / 100 ml, 2150 ppm potassium and 21.7 ppm sodium.

Fig. 1. Kalpa Prathiba

- **Kalpa Dhenu (Fig. 2):** The variety is a regular bearer, relatively tolerant to drought and suited for West coast region of the country and the Andaman and Nicobar Islands. The palms of this variety are tall, robust and bear large, green fruits. The variety produces annually, on an average, 15012 nuts / ha, 3.66 tons copra / ha and 2.40 tons oil / ha. This variety has the potential to produce, on an average, 22794 nuts, 5.56 tons of copra and 3.64 tons of oil per hectare. The tender nut water of this variety contains 4.92 g total sugars / 100 ml, 1.3 mg free amino acids / 100 ml, 2650 ppm potassium and 24.6 ppm sodium.

Fig. 2. Kalpa Dhenu

- **Kalpa Mitra (Fig. 3):** The variety is a regular bearer, relatively tolerant to drought and produces large, yellowish green, oval shaped fruits. The variety is suited for west coast region of the country and the State of West Bengal. The variety produces annually, on an average, 13973 nuts / ha,

3.37 tons copra / ha and 2.24 tons oil / ha. The tender nut water of this variety contains 5.7g total sugars / 100 ml, 1.3 mg free amino acids / 100 ml, 2150 ppm potassium and 23.5ppm sodium. This variety has the potential to produce on an average 22429 nuts, 5.41 tons of copra and 3.60 tons of oil per hectare.

Fig. 3. Kalpa Mitra

- **Kalparaksha (Fig. 4) :** *Kalparaksha* (a selection from Malayan Green Dwarf) was recommended for release as a high yielding coconut variety with field resistance to coconut root (wilt) disease, suitable for cultivation in the root (wilt) diseased tract. *Kalparaksha* recorded an average yield of 64.5 nuts / palm / year (average of the last five years), copra content of 185 g / nut and oil yield of 1.60 tons / ha.

Breeding for resistance / tolerance to coconut root (wilt) disease

A comprehensive survey involving 664 palms in 126 farmers plots in disease hotspots

Fig. 4. Kalparaksha

of Alappuzha, Pathanamthitta and Kottayam districts revealed that Chowghat Green Dwarf is relatively resistant to root (wilt) disease with only 14.5 % disease incidence and yielding on an average 76.5 nuts / palm / year in comparison to West Coast Tall with 85.2 % disease incidence and 39 nuts / palm / year. In "hotspots" of Kottayam, a total of 231 disease free palms were identified. Fifty palms were subjected to serodiagnosis out of which 29 were found to be negative to root (wilt) disease.

The CGD x WCT hybrid, planted during 1991, gave a cumulative average yield of 70 nuts / palm / year, even though sixty eight percent of hybrids recorded the incidence of root (wilt) disease.

Anatomical studies in dwarf varieties revealed that lower cuticle thickness was more in MGD (10.27 µm) compared to other varieties. Younger leaves of CGD had higher values for leaf thickness (1077.65µm), parenchyma width (47.29 µm) (between the vascular bundle and epidermis), and larger distance between the stomata to phloem tissues (88.25 µm). These morphological / structural features may be some of the factors contributing for higher level of resistance reported in CGD and MGD.

Evaluation of arecanut germplasm in sub Himalayan terai region

A total of 71 accessions of arecanut are under evaluation for the Sub-Himalayan Terai Region of West Bengal. Among the accessions planted during 1988, Mohitnagar performed well with respect to number of inflorescences,

number of nuts and fresh weight of nuts. Accessions from Nalbari (1.856 kgs of chali/ palm) followed by J & K Hills (1.674 kgs chali) and Kamalpur(1.458 kgs) recorded very high yields, as revealed from the trial started in 1994.

Crop improvement programmes on cocoa

Under the Asia Pacific breeding initiatives, seeds of 2 hybrids *viz.* PBC-123 x LAFI-7 and QH-22 x NA-33 were received from Malaysian Cocoa Board. They showed 89 and 77% germination in poly bag nursery. Among the Malaysian collections, the clones IV-20, IV-84 and I-56 recorded the highest yield of 71, 66.3 and 62.8 pods/ tree/ year and two trees (IV-20 and II-51) yielding more than 100 pods were identified. Among Lalbagh collections, the Nanay series viz. NA-33 and NA-242 yielded more pods. Among 42 Nigerian collections, the clones NC-25, NC-37, NC-52, NC-57 and NC-48 yielded 56.5, 50.0, 47.75, 46.75 and 46.63 pods/ tree/ year, respectively. Six progenies PI.3, PI.4, PI.1, PIII.6, PIII.3 and PII.5 of the crosses SCA-6 x IMC-67, NA-33 x ICS-89, NA-31 x ICS-1, ICS-6 x SCA-6 and I-14 x NC-42/94 have yielded an average of 60, 58, 56, 54.8, 53.6 and 51 pods/ tree/ year respectively with high nib recovery. Among the clones NC-45/53 and NC-39/102 have yielded more than 70 pods/ tree/ year. Analysis of fat content in 152 samples revealed that one progeny and 4 clones had more than 45% fat.

Commercial Seed production

- During the period, 1,01,303 coconut and 3,09,190 arecanut seednuts were produced.
- A total of 99,000 cocoa grafts of high yielding clones, hybrids and varieties were produced and sold to farmers, Kerala Agri. Dept. and other nurseries.
- A total of 1200 rooted cuttings of pepper (var. karimunda, panniyur and other promising varieties) were raised as quality planting materials in North-Eastern Region for distribution to farmers and developmental agencies.
- A total of 10,000 arecanut seedlings of the promising HYV (Mangala, Sumangala, Sreemangala, Mohitnagar and Kahikuchi selection) were produced and supplied to various NGO's, farmers and other agencies in North-Eastern Region.

BIOTECHNOLOGY

Nut set in coconut palms using cryo-preserved pollen

Nut set in COD and WCT palms pollinated with cryopreserved pollen was comparable to the nut set under natural pollination.

Fig. 5. Nut set in COD, pollinated with cryopreserved WCT pollen

Molecular characterization of coconut germplasm

RAPD markers were used to analyze the genetic diversity and relationship among 28 palms representing three yellow dwarf coconut accessions viz. Malayan Yellow Dwarf, Kulasekaram Yellow Dwarf and Andaman Yellow Dwarf. Based on the RAPD banding pattern, the mean heterozygosity was 0.157 for KYD, 0.153 for MYD and 0.039 for AYD. Similarity matrix based on Jaccards coefficient indicated a close association of the two indigenous yellow dwarfs (AYD and KYD) with the exotic yellow dwarf (MYD).

Fifty nine palms comprising of seven germplasm accessions from Lakshadweep Islands were characterized using nine RAPD and five ISSR markers. Mean heterozygosity

varied from 0.096 to 0.191. Hierarchical analysis of molecular variance indicated that most of the variation (88%) was found between accessions and only 12 % of the variation was found among accessions.

RAPD markers linked to sex determination in Palmyrah (*Borassus flabellifer* L.)

Random amplified polymorphic DNA (RAPD) technique was used to identify DNA segments, linked to sex determination in dioecious palmyrah. The palm is slow growing perennial and has no distinguishing features to identity the sex until flowering. A total of 180 random decamer primers were screened to identify sex-linked markers in this palm. A 600 bp male- specific DNA fragment, generated with the primer OPA- 06 was identified during bulk segregant analysis. When tested individually, this fragment was present in all males, but absent in all female entries. The male-specific band produced by OPA- 06 is tightly linked to the male sex-determining locus in palmyrah. This is the first report of a sex-specific molecular marker in *Borassus flabellifer*.

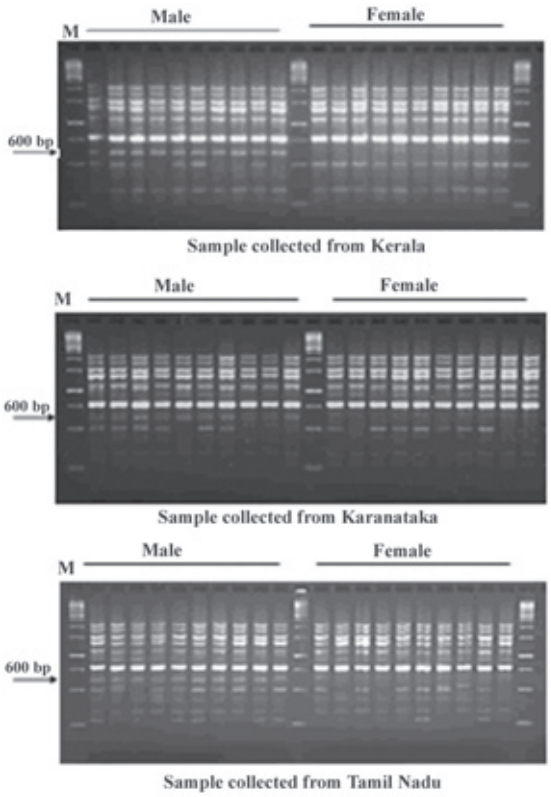

Fig. 6. RAPD banding profiles showing male specific bands of 600 bp

Clonal fidelity in arecanut

DNA was extracted from leaf samples of tissue culture derived plantlets (via direct somatic embryogenesis from inflorescence explants) of YLD resistant palms from hotspot garden of South Kanara District of Karnataka. Random Amplified Polymorphic DNA (RAPD) markers were used to evaluate the clonal fidelity of the plantlets. DNA from two mother palms and eight plantlets from each mother palm were assessed using 10 highly polymorphic primers. Uniform banding pattern was noticed in both mother palms and plantlets with all the 10 primers. The uniformity could be due to plantlet regeneration from direct somatic embryo from inflorescence explants.

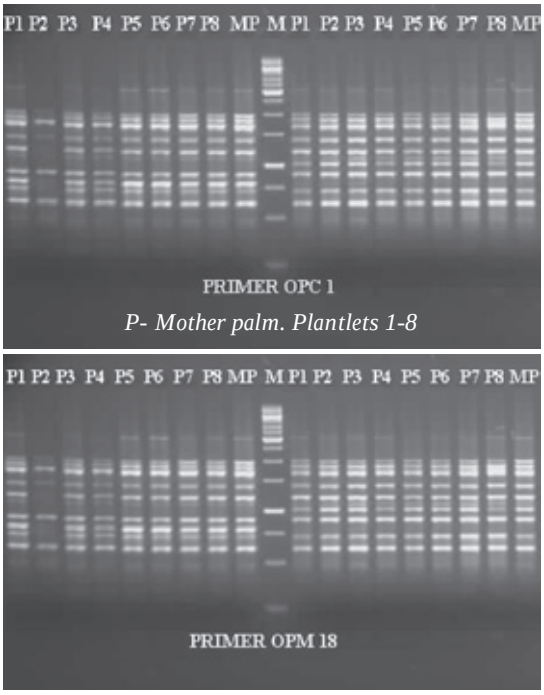

Fig. 7. RAPD patterns of clonal fidelity in arecanut

BIOINFORMATICS

Molecular characterization of plant growth promoting rhizobacteria (PGPR)

Molecular characterization of 40 different morphotypes of fluorescent pseudomonads isolated from coconut leaf vermicompost was done. DNA was isolated from these isolates and RAPD analysis was carried out. Primers of OP A series 1-20 were screened for selecting polymorphic primers. Primers OP A1, A4, A5, A7 and A9 exhibited polymorphism. Based on the RAPD analysis, a dendrogram of the phylogenetic relationship among the morphotypes were constructed.

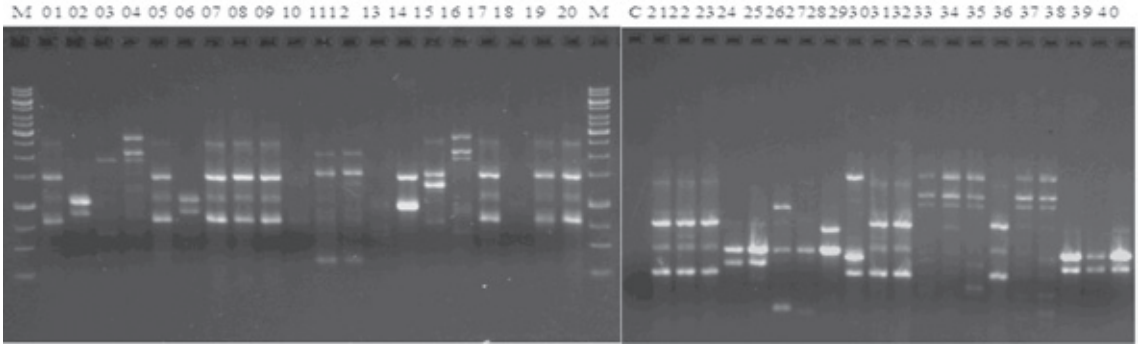

Fig. 8: RAPD profile of fluorescent pseudomonads from coconut leaf vermicompost with OPA 10 primer (Lane M is 1 kb ladder; Lanes 01 to 40 are fluorescent pseudomonads; C is control)

CROP PRODUCTION

Suitable intercrops for coconut gardens in coastal sandy soils

Banana variety Grand Naine

In coastal sandy soil, husk and coir pith application as amendments had significantly influenced the productivity of banana varieties. Banana variety Grand naine performed better under husk burial and coir pith application treatments yielding 24.6 kg/bunch compared to control (16.8 kg/ bunch).

Ash gourd

Coir pith and husk application had significantly influenced the growth and yield parameters of ash gourd when grown as intercrop in coconut garden. Higher fruit yield was obtained under husk application (12.8 t/ha) and it was on par with coir pith application (11.84 t/ha) and significantly differed from the control (4.21 t/ha).

Fig. 9. Banana intercropping in coconut garden

Economics of the coconut based mixed farming system

Coconut based farming system involving coconut with integration of grass, pepper (trailed on coconut), banana (on the border of the garden), dairy and poultry resulted in a net return of Rs.1,29,070/ha during 2006-07. Coconut, milk yield and broiler's sale accounted for 91 per cent of the revenue generated from the system.

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. Among the organic cultivation treatments, vermicomposting in trenches, application of biofertilisers (Azospirrillum and Phosphobacteria) and cover cropping in the basin resulted in higher copra and nut yield which was on par with other organic cultivation treatments and significantly differed from the control treatment for WCT. However, the treatment vermicomposting in trenches, application of biofertilisers (Azospirrillum and Phosphobacteria) and raising vanilla in the interspaces and pepper (trailed on coconut) resulted in higher copra and nut yield which was on par with other organic cultivation treatments and significantly differed from the control treatment for D x T.

Precision farming in coconut

In general, highly-weathered soils in the high rainfall zones commonly suffer from multiple nutrient deficiencies. The regression analysis of the soil available nutrients at different levels to coconut yield indicated existence of multiple nutrient limitations. Soil available nutrient and individual palm yield data were analysed for Multiple nutrient Limitation Hypothesis in the red sandy loam soil at CPCRI Kasaragod. In the analysis it was found that increasing level of available K at the high level of total N had a linear increasing effect on the coconut yield suggesting the N and K have a co-limiting role.

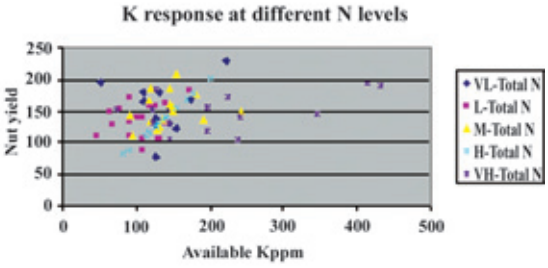

Fig. 10. Coconut yield at different total N levels to available K

Drip-fertigation in arecanut

Fertigation of 75% NPK at 10 days frequency registered maximum yield (4017 kg ha^{-1}), which was closely followed by fertigation of 75% NPK at 20 days frequency (3924 kg ha^{-1}) and fertigation of 100% NPK at 20 days frequency (3579 kg ha^{-1}). A strong linear correlation (R^2=0.914) was observed between fertigation level and total root biomass. The root biomass increased considerably from 3.23 (no fertilizer) to 7.99 kg per palm (75% NPK). Significant relation between root biomass and organic carbon content in soil based on polynomial regression (R^2 = 0.769) was also noticed. Water use efficiency (WUE) was significantly superior at 75% NPK applied at 10 days interval over 100% NPK applied at same interval. Agronomic nutrient use efficiency (ANUE) was significantly higher at 25% NPK (14.9 kg kernel produced per kg nutrient applied). Fertigation up to 75% NPK provided a higher ANUE than the combination of drip irrigation and soil application of 100% NPK indicating greater production at lesser application rates. The yield economics indicated that 75% NPK fertigation at 10 days interval was highly profitable with highest net returns per rupee investment of 4.57 followed by 75% NPK fertigation at 20 days interval (4.44).

Potassium solubilizing microorganisms

Forty eight isolates of potassium solubilizing microorganisms were isolated from sandy soil (CPCRI Farm, Kasaragod) and 40 potassium solubilizing bacterial isolates were obtained from red laterite soil (Manya, Kasaragod) using three different media based on Aleksandrov medium. Clearing zones of K-solubilization of upto 7 mm were obtained when potassium aluminosilicate was used as the insoluble source of potassium.

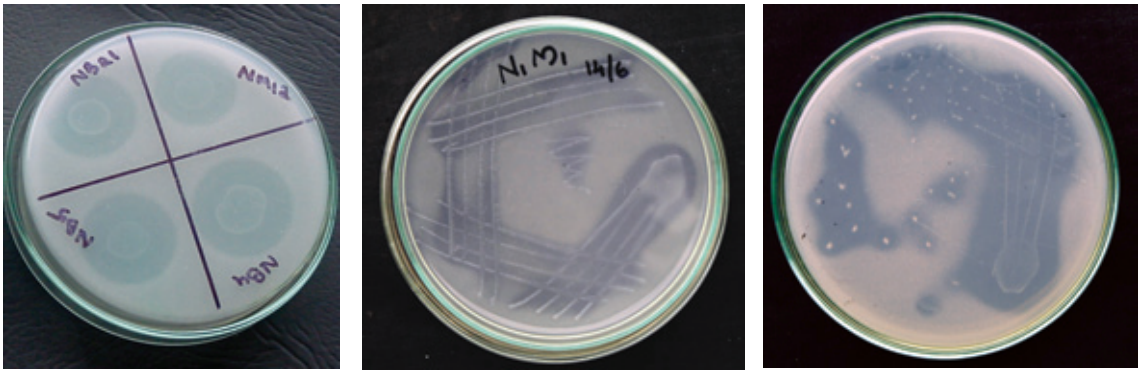

Fig. 11. Potassium solubilization by bacterial isolates from sandy and laterite soils on Aleksandrov medium.

Fluorescent pseudomonads from coconut leaf vermicompost

Forty fluorescent pseudomonad isolates were obtained from coconut leaf vermicompost, out of which 34 produced IAA in varying quantities, 9 being the highest producers. Siderophore production and P-solubilization was observed in 37 of the isolates. P-solubilization zones of upto 22 mm were recorded on Pikovskaya agar medium. Five isolates had high P-solubilization potential. Among siderophore producers, 14 were categorized as high producers, giving orange halos of iron sequestration of upto 20 mm on CAS agar medium.

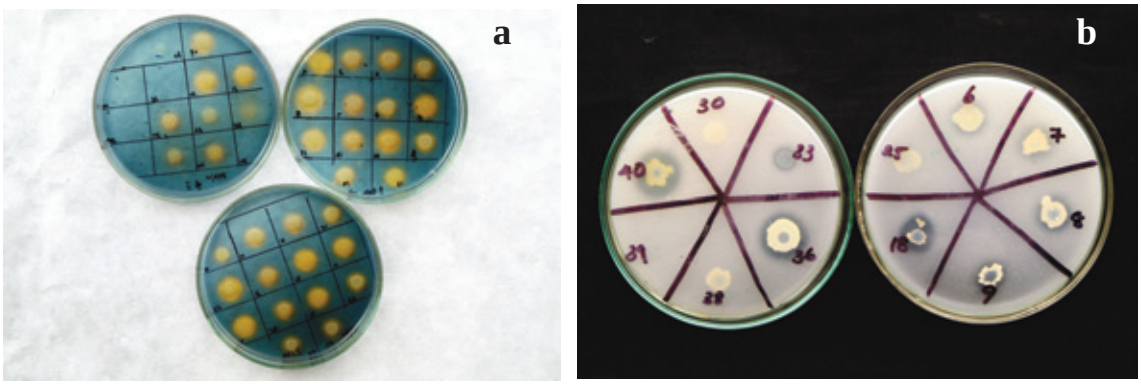

Fig. 12. Siderophore production (a) and phosphate solubilization (b) by fluorescent pseudomonads obtained from coconut leaf vermicompost

Endophytic and rhizospheric PGPR from coconut and cocoa

A total of 315 potential plant growth promoting rhizobacterial isolates were obtained from rhizosphere and endorhizosphere of cocoa growing in different agro-climatic zones in Karnataka (Vittal, Kidu) and Kerala (Kasaragod, Vata, Kozhikode, Wyanad) and 102 isolates were obtained from rhizosphere and roots of coconut (WCT and COD) from Kidu (Karnataka). These isolates were evaluated for growth promoting parameters like nitrogen-fixing capacity, phosphate solubilizing capacity, ammonification, IAA production, HCN production and siderophore production.

Forty two isolates were tested for antibiotic production, chitinase and ACC deaminase activity, out of which 7 were found positive for antibiosis, 10 tested positive for ACC deaminase activity but none of them showed chitinolytic activity. The antibiotic producers were studied for antagonistic properties

against *Ganoderma* sp. and *Thielaviopsis paradoxa* on PDA, KB, NA and Waksman agar media by dual culture technique.

Seedling bioassay was conducted with 29 PGPR isolates on cowpea and paddy. Four endophytic bacilli and 7 rhizospheric isolates from coconut stimulated root growth in paddy and 3 fluorescent pseudomonads from coconut rhizosphere stimulated root and shoot growth of cowpea seedlings. The PGPR isolates designated as F6, F14 and F33, which were isolated from coconut rhizospheres from Thopumpady, Kunnumkkai and Pollachi, respectively, produced high levels of IAA and showed early germination and stimulated root growth in paddy on soft agar plates in Environmental Growth Chamber conditions.

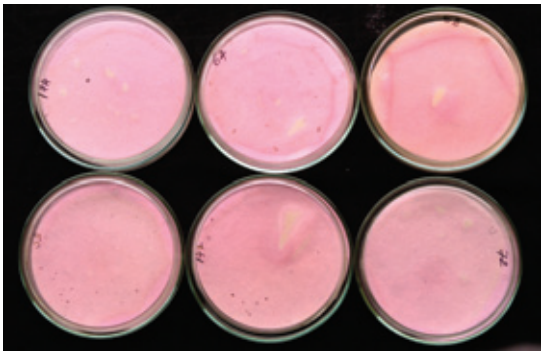

Fig. 13. IAA production by pseudomonads fluorescent

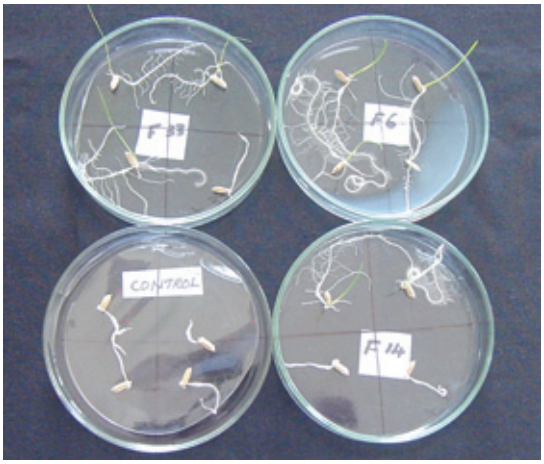

Fig. 14. Seedling germination and pseudomonads growth of paddy seeds on bacterization with F6, F14 and F33 PGPR isolates

Supply of bioresources to end users

About 70 farmers, 200 school and college students were demonstrated the technology of vermicompost and mushroom production from coconut leaves and to popularize the technologies around 1,65,000 *Eudrilus* sp. earthworms, 12 tonnes of coconut leaf vermicompost, 105 kg of mushroom spawn (*Pleurotus* sp. and *Calocybe indica*) and 20 kg of fresh mushrooms (*Pleurotus florida*) were produced and sold to farmers, women entrepreneurs and self employed youths during this period.

PHYSIOLOGY AND BIOCHEMISTRY

Carbon sequestration in areca-cocoa cropping system

The cocoa-areca mixed crop not only gives a sustainable production, but also serves as a good system for biomass production and carbon accumulation. The carbon and biomass estimations have shown that annual increments ranged from 0.55 to 2.98 t/ha/year in carbon and 1.38 to 7.11 t/ha/year over the 15 year period in areca and cocoa (Table 1). The quantum of carbon sequestration was between 2.02-3.89 t/ha/year and 5.14-10.94 t/ha/year in cocoa and areca, respectively. Thus there is considerable amount of net sequestration of CO_2 in the system.

Projections of coconut relative yield changes due to climate change

Using coconut simulation model, yields were simulated for 13 agro-climatic zones represented by 16 centres. These areas contribute over 90% to the coconut production in India. Simulations for yield projections were done for HadCM3 climate change storylines viz., A2a, B2a and A1F for 2020, 2050 and 2080 scenarios. The CO_2 projections of Bern CC model, temperature projections of HadCM3 model, location weather data for past 30 years, major soil type of the agro-climatic zone and currently followed farmer's practice for crop

Table 1. Net primary productivity and CO_2 sequestration in cocoa and arecanut

	Annual increments (t/ha/yr) in cocoa			Annual increments (t/ha/yr) in areca		
	3-5 years	6-8 years	9-15 years	3-5 years	6-8 years	9-15 years
Biomass	2.66	2.06	1.38	4.21	7.11	3.34
Carbon stock	1.06	0.83	0.55	1.78	2.98	1.40
Net CO_2 sequestration	3.89	3.05	2.02	6.53	10.94	5.14

management are used as inputs into the coconut simulation model. Relative impacts on yield were worked out at district level in an agro-climatic zones and up-scaled to state and national projections for impacts of climate change on coconut yield. Sensitivity analysis for CO_2 and temperature was also done using simulation model.

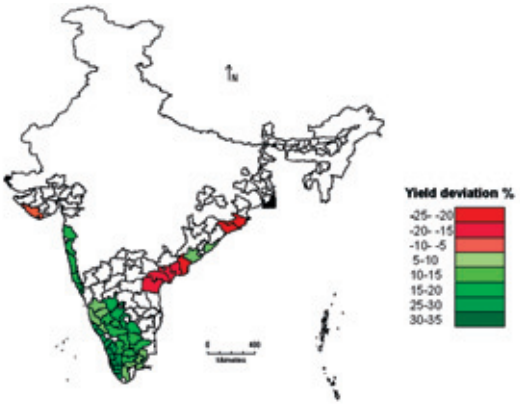

Fig. 15. Coconut yield relative deviations from current yields due to climate change – A2a 2080

Results indicate that under all storylines, coconut productivity is projected to go up by up to 10% during 2020, up to 16% in 2050 and up to 36% in 2080 over current yields only due to climate change. However, in east coast yield is projected to decline by about 2% in 2020, 8% in 2050 and 31% in 2080 scenario over current yields due to climate change. Special variations exist for these projections. Yields are projected to go up in Kerala, Tamil Nadu, Karnataka and Maharastra while they are projected to decline in Andhra Pradesh, Orissa and Gujarat. It is also estimated based on the past 10 year domestic consumption trend that coconut consumption per capita may decline. However, projections show that demand for coconut may increase due to increase in population in the country. This brings to the fore that demand supply gap will increase in future even as coconut production is expected to rise due to climate change alone with existing management being practiced by the farmers. Thus to improve the productivity, more adoption of farming technologies by the farmers is essential, not only to bridge the supply demand gap but also to exploit the export opportunities.

CROP PROTECTION

Diseases

Coconut root (wilt) disease

PCR amplification of rDNA from root (wilt) affected coconut palms with phytoplasma specific primers P4 and P7 produced two amplicons of approximately 700bp and 450bp sizes. After gel purification and cloning of the 700 bp fragment, sequencing was done. Comparison of the sequence with other sequence data in the GenBank showed 97% homology to the root (wilt) pathogen sequence (AY 158660) of Sharmila *et al.* (2004) . Further studies using more phytoplasma specific primers as well as sequencing of the 450bp fragment are in progress.

Management of bud rot disease of coconut

Severe incidence of bud rot of coconut caused by *Phytophthora palmivora* was noticed in the disease endemic areas in Kasaragod, Calicut, Kannur and Wayanad districts of

Kerala due to continuous high rainfall and non-adoption of prophylactic control measures.

The large scale field trial laid out in six coconut gardens of Chittarikkal Panchayat of Kasaragod district indicated that placing Indofil M-45 sachets in the leaf axils (two sachets of 2g each on two sides of the spindle leaf), was superior to other treatments, especially as prophylactic treatment.

Effect of plant extracts and plant products on growth of virulent isolates of *Lasiodiplodia theobromae*

Among 52 plant extracts tested *in vitro*, garlic (*Allium sativum*) bulb extract and leaf extracts of all spice (*Pimenta dioeca*) and clove (*Syzygium aromaticum*) each at 4% concentration were found to be very effective in inhibiting the growth of three virulent isolates of *L. theobromae*, the causal organism of fruit rot and immature nutfall of coconut. The extracts of *A. sativum* at 10% and *P. dioeca* and *S. aromaticum* each at 8% concentration were fungicidal to the selected three isolates of *L. theobromae*.

Among 10 plant products screened *in vitro*, clove oil 2%, eucalyptus oil 1%, Eco Neem Plus (a botanical insecticide containing *azadirachtin* 1%) and, neem oil + garlic + soap mixture 5% concentration were found very effective in inhibiting the growth of selected *L. theobromae* isolates. Eco neem plus at 8% and neem oil + garlic + soap at 10% were found fungicidal to all three isolates.

The field trial laid out to find out the efficacy of plant extracts and plant products in controlling fruit rot and immature nutfall of coconut caused by *L. theobromae* revealed that garlic bulb extract (10%), Eco-neem plus (8%) and neem oil + garlic extract + soap mixture (10%) were equally good in controlling the disease. The disease incidence was less than 10% in the plots with these treatments. But, fungicides such as Bavistin, Companion and Indofil M-45 were superior to plant extracts and plant products. As cost of Eco-neem plus is very high, spraying this product to control *L. theobromae* infection in coconut is not economically feasible.

Integrated management of coconut leaf rot disease with biocontrol agents

Control of leaf rot disease with biocontrol agents *Bacillus subtilis* and *Pseudomonas fluorescens* – especially in consortium formulation along with phytosanitation has been successfully evolved and amelioration of the disease affected palms with such bioagents proved in field trials. Positive influence such as vigorous growth and leaf rot disease suppression in seedlings through bio-treatment of coconut seeds/ seedlings with these biocontrol agents has been also established.

Fig. 16. Seedlings raised through biopriming of coconut seed nuts with organically amended biocontrol agents (Right row: Control)

Mass production and use of biocontrol agents in the integrated management of coconut leaf rot disease

Common bacterial (*Bacillus subtilis* and *Pseudomonas fluorescens*) and fungal (*Trichoderma viride*) biocontrol agents could be

periodically mass multiplied, processed into bioformulations and distributed to rural people, women, youth etc. under various programmes conducted. Awareness *cum* training programmes of mass production – use of biocontrol agents and their packaging techniques were conducted through in campus-off campus trainings, field visits, interface meetings, field school and other awareness measures in various districts of Kerala and in Theni district of Tamil Nadu, benefiting 1167 participants. Field demonstrations on utilization of bio control agents, distribution of promotional literature etc. were also performed in diverse locations, and knowledge percolated into rural masses.

Fig. 17. Production of biocontrol agents by farmer women

Pests

A talc based preparation with virulent strains of *Hirsutella thompsonii* (CPCRI -19; CPCRI. 51(2)) has shown promising results in the preliminary field screening trial for management of coconut mite.

Surveillance on pest incidence on coconut showed high incidence of the white fly *Aleurocanthus arecae* David (Aleurodidae) infesting lower whorl of coconut leaves in various districts of Kerala during post monsoon period.

Olfactory response of *Goniozus nephantidis* a parasitoid of *Opisina arenosella*

During the choice test in Y maze it was observed that the starved females of *G. nephantidis* were attracted more to arm having honey as compared to arm having *Opisina*, *Corcyra* larvae, *O. arenosella* frass.

Parasitoids when fed tend to switch over from food searching behavior to host searching behavior. When provided a choice between honey and *Opisina* larvae / *Opisina* larval frass and honey preferred to orient towards the arm having *Opisina* larva and its frass. The orientation response of *G. nephantidis* was more to *Opisina arenosella* hemolymph followed by *Opisina arenosella* larval frass, *Corcyra* larvae and *Opisina* larvae.

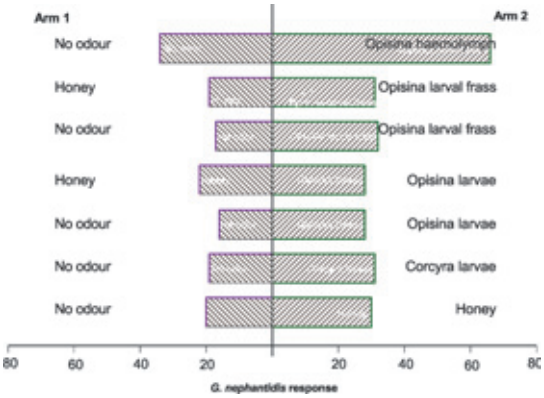

Fig. 18. Goniozus nephantidis response to olfactory signals

EAG Response to volatiles from host and in products

The EAG response of males to different volatiles of host and its product was comparatively lower than that of females. The comparisons of volatiles indicate that the olfactory response was maximum to larval hemolymph in both male and females. Females caused higher response to *Opisina* larval frass. In both cases of male and female response to *Opisina* larvae damaged leaf was more than the mechanically damaged leaf. This clearly establishes the role played by host odors and plant cues serve as a short range cues for parasitoids.

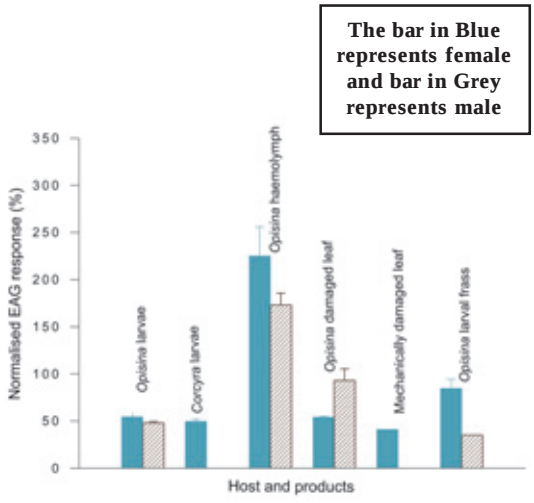

Fig. 19. Electrophysiological response of G. nephantidis adults to host volatiles

POST HARVEST TECHNOLOGY

A mechanical testa remover with a capacity to process 200 nuts per hour has been developed to achieve greater efficiency in removal of testa from kernel of mature coconut. As removal of kernel testa is the first step in production of value added products such as coconut chips, virgin coconut oil, it will greatly help to accelerate the process of product development.

Fig. 20. Jaggery treated dehydrated coconut chips

A coconut grating machine has been prepared to grate the kernel after removal testa for production of virgin coconut oil. A small scale fermentation plant of 25 litre capacity was developed for cottage industries. Recovery of oil varied from 15% to 18% in fermentation process.

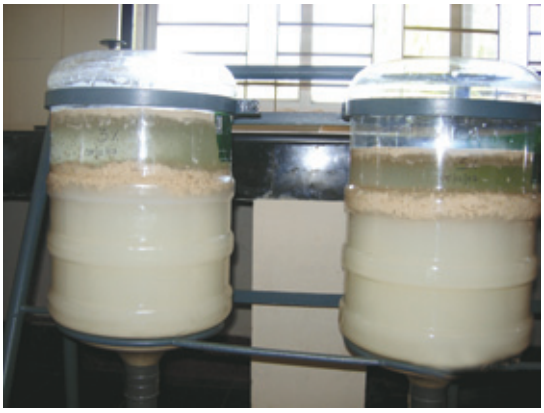

Fig. 21. Fermentation of coconut milk for separation of oil

Fig. 22. Virgin coconut oil prepared after fermentation of coconut milk

The technology for production of coconut vinegar has been refined to produce better quality vinegar which will be more acceptable to the consumers. The filtration technique will enable to overcome the problem of unpleasant odour and colour.

SOCIAL SCIENCES

Cyber Extension Programmes

The Research-Extension-Farmer Interface facilitated through video conferencing under Cyber Extension Project was formally inaugurated by Dr. HP Singh, Deputy Director General (Hort.), ICAR, New Delhi at CPCRI, Kasaragod on 7.4.2007. Shri Kunhahammad Master, President, District Panchyat, Kozhikode participated in the interaction and presented the coconut cultivation scenario in the Kozhikode district and problems faced by coconut farmers in the district. Selected farmers and extension personnel from Kozhikode district participated in the interface programme. Research-Extension-Farmer Interface facilitated through Video Conferencing was also conducted on 17-09-07 in which a team of Scientists at CPCRI, Kasaragod and a group of extension personnel and farmers at Collectorate, Malappuram participated.

Fig. 23. Dr. HP Singh, Deputy Director General (Hort.), ICAR inaugurating the video conferencing facility

Kisan mela celebration

As part of the efforts to strengthen the technology transfer programmes, a Kisan mela was organized at Central Plantation Crops Research Institute (CPCRI), Kasaragod on 19th May 2007. About 1500 farmers participated in the Kisan mela, besides large number of entrepreneurs, members of women self help groups and extension personnel. Mr. Mullakkara Ratnakaran, Hon'ble Minister for Agriculture, Kerala state, inaugurated the Kisan mela. An exhibition was organized in connection with Kisanmela in which improved technologies from CPCRI and other research institutions, programmes of development agencies, farm input agencies and products of women self help groups in farming were exhibited.

Fig. 24. Mr. Mullakkara Ratnakaran, Hon'ble Minister for Agriculture, Kerala state, inaugurating the Kisan mela

Training programme for extension personnel

A training programme on "Horticultural crops for multiple cropping in coconut garden – Integrating innovations and focusing on stakeholder participation" for selected extension personnel was sponsored by State Horticulture Mission-Kerala. Accordingly, the training programme for the 1st batch of extension personnel was conducted during 1-7 February, 2008 at CPCRI, Kasaragod.

Forecasting of coconut production

Field survey was conducted during May-August 2007 in 18 major coconut growing districts in the country to provide production forecast of coconut for the agricultural year 2007-08. Based on data collected from a total of 12,798 palms spread over 673 locations in the selected district, the all India forecasted production of coconut for the year 2007-08 was worked out to be 15.5 billion nuts which is more than 8.3% over the forecasted production for the year 2006-07. The forecasted production of coconut for the year 2007-08 in Kerala, Karnataka, Tamil Nadu

and Andhra Pradesh is respectively 6987, 2208, 3920, and 876 million nuts.

Yield loss due to Koleroga in Karnataka

A quick field survey was conducted during the last week of September, 2007 in Dakshina Kannada, Udupi, Chickmagalur, Shimoga and Uttara Kannada districts of Karnataka to assess the yield loss in arecanut due to *Koleroga*. To cover large number of gardens with limited time and resources, purposive sampling method has been used in the selected taluks of each districts. To take observations, the gardens were selected systematically in each taluk. The estimated loss was maximum in Udupi district (49%) followed by Uttara Kannada (43%), Dakshina Kannada (40%), Chickmagalur (33%) and Shimoga (29%).

Price trend in coconut and arecanut

The price of coconut showed downward trend in the later part of the year 2007, but later recovered. The international price of coconut and coconut products showed an increase, leading to narrow down difference between domestic and international prices.

In the month of January and February, 2007 the price of new supari slipped to Rs. 6300/- quintal in the back drop of the poor quality arecanut arrival in the market. During the month of May –August the prices remained stationary to the range of Rs. 7000-7966/-. In respect of Chol grade (old) the prices were more or less stable (Rs. 8000-8600/-). On an average there was only 1.2 to 1.4 % hike in price of arecanut compared to 2006. The chol grade of arecanut (which is stored), fetches premium price, which is 16% more than season's price of new supari.

IFAD Project on "Overcoming Poverty in Coconut-Growing Communities: Coconut Genetic Resources for Sustainable Livelihoods in India"

CPCRI is implementing the project sponsored by Bioversity/COGENT/IFAD in three sites, viz., Pathiyoor, Thodiyoor and Devikulangara of Alappuzha district, Kerala. In all the three project areas, CBOs were established and registered under official Government agencies.

The microcredits were mainly utilized for intercropping, nursery establishment, livestock rearing and local feed production, high value products, mushroom production and azolla cultivation. Total of 1257 members were trained on microcredit and CBO management, intercropping aspects, livestock rearing and local feed formulations, nursery management, product diversification and nutritive foods, vermicomposting, mushroom production, coir spinning and packing and labeling. In Pathiyoor, majority of the members utilized microcredit for intercropping activities (48%), whereas at Thodiyoor (56%) and Devikulangara (43%), it was for livestock integration.

As part of conservation of genetic resources, diversity fair was organized with all the three communities. They were trained on identification of varieties, selection of mother palms and nursery management including polybag seedlings. Characterized four tall palms and two dwarf types. Community nursery was established with 2400 seed nuts collected from these varieties.

Fig. 25. Inaugural planting of elite seedlings by Dr. Shantanu Mathur in farmer's field

Kisan mela celebration

Kisan Mela was conducted at CPCRI, Regional Station Kayangulam on 23rd February, 2008. The Mela was inaugurated by the Director, CPCRI. About 600 farmers, extension officials and local representatives participated in the programme. Two panel discussions one on latest coconut technologies and the other on developmental programmes for coconut were held in the forenoon. Visit to experimental fields, exhibitions and farmers' interaction were also arranged. CPCRI, Coconut Development Board, Krishi Vigyan Kendra and 13 SHGs participated in the exhibitions. Mr.C.K.Sadasivan, M.L.A, Kayamkulam constituency delivered the valedictory address and Mr.A.Nazarulla, Municipal Chairman of Kayamkulam presided over the function. Mr.Thomas Mathew, Chief Coconut Development Officer delivered the key note address and Mrs.Shamila Basheer, President, Krishnapuram Panchayat, Mr.C.S.Basha, councilor, Kayamkulam Municipality offered felicitations for the functions.

Fig. 26. Director CPCRI leading Director of Agriculture, Govt. of Kerala through various exhibition stalls set up by farmers during kisan mela.

Training on arecanut production strategy

A training programme on Market Led production strategies for arecanut and cocoa was conducted from 12-18 December, 2007, at CPCRI, RS, Vittal. Officers from Agriculture University, State Horticulture Department and CAMPCO participated.

Krishi Vigyan Kendra, Kasaragod

1. Training programmes

Organized a total of 166 training programmes with the participation of 3872 trainees (1331 men and 2541 women) including practicing farmers, farm women, women self help groups, rural youth and extension functionaries on various topics in the disciplines of Agricultural Extension, Agricultural Engineering, Crop Production, Plant Protection, Home Science, Horticulture and allied enterprises. Out of total training programmes organized, 65 were on-campus and 101 were off-campus wherein 1526 (630 men and 896 women) and 2346 (701 men and 1645 women) trainees participated, respectively.

Organized a total of seven training courses of 2 days duration each on cashew production technologies for 214 (170 men and 44 women) farmers belonging to Kasaragod district under State Horticulture Mission Programme.

2. Front line demonstrations

Organized a total of 160 demonstrations in the farmers fields and successfully introduced the high yielding varieties of various crops as well as production technologies viz., PKM-2 (Annual Moringa), Konkan Amruta (Kokum), tissue culture banana as intercrop in coconut gardens (Graintnaine), stem bleeding management in coconut, drought management practices in coconut gardens, fodder grass and pineapple as intercrop in coconut gardens in coastal sandy soils, management of inflorescence die back in arecanut, cocoa as mixed crop in coconut gardens and introduction of aluminum cooker developed by Gadag KVK among WSHGs.

3. On-farm testing of technologies

(a) Evaluation of SRI method in paddy: An experiment was conducted in 10 farmers fields

at Puthigae panchayat under paddy-paddy fallow ecosystem for effective utilization of available irrigation water in paddy cultivation. The rice variety Athira was used for the experiment. Two treatments taken up in this experiment were T1 - SRI method and T2 – Control (farmers practice). An average yield of 6.8 t / ha recorded in T1 as compared to 4.2 t / ha in control. It shows the tested SRI technology gave an increased yield of 2.6 t / ha. The BC ratio of this technology was found to be 1.3.

(b) Coir pith composting using poultry manure as amendment : An experiment was conducted in 10 farmers fields at Nileswer panchayath for coir pith composting using poultry manure as amendment. Huge quantity of available un-decomposed coir pith was used for the experiment. Two treatments taken up in this experiment were T1 - Coir pith compost with organic materials like poultry manure (10%), lime (0.5%) and rock phosphate (0.5%) and T2 – Control (Coir pith composting with urea and *Pleurotous sp*.). A total of 62 kg compost was collected from 100 kg coir pith. Observations indicated that 5-7 days more time was taken for decomposition than compared to coir pith composting with urea and *Pleurotous sp.* The BC ratio of this technology was found to be 1.6.

Fig. 27. Coir pith composting using poultry manure as amendments

4. Womens' Cell activities

Formulated and implemented various training courses for the benefit of farm women under Womens Cell of KVK. Trained a total of 1359 women participants of various categories through organization of 22 on-campus and 35 off-campus training programmes with 486 and 873 participants, respectively. The topics covered under these courses were Nutrition care for mother and child, Value added products from coconut, Nutrimix supplementary products, Curry powder preparation, Low cost convectional methods for bakery products, Low cost weaning foods, Seasonal fruits and vegetables processing, Jasmine cultivation, Vegetable cultivation, Mushroom cultivation, Food Processing, Vermicomposting, Masala powder preparation, Role of fruits in diet, Infant nutrition, Hygiene and health and Nutrition garden.

5. Extension activities/Services

Carried out a total of 794 activities comprising of field days, kisan gosthi, kisan melas, exhibitions, film show / Video CD, advisory services, agricultural seminars, farmers visit to KVK, awareness campaigns, field visits, demonstrations etc where in 10978 farmers (7883 men and 3095 women) and 674 extension personnel (489 men and 185 women) were appraised of modern production technologies of various crops and allied enterprises. Further, faculty participated in two radio talks, published three popular articles, and 12 activities covered in news papers.

6. Seeds/planting materials

A total of 19.2 kg quality seeds of bitter gourd, snake gourd, amaranthus, bhendi, cowpea, cucumber, ash gourd, pumpkin and 4800 quality seedlings of mango, jack fruit, suppota, chamba, egg fruit, rambutan, pepper were provided to 388 farmers of Kasaragod district.

Krishi Vignana Kendra, Alleppey

KVK Alleppey has conducted 53 on campus trainings and 30 off campus trainings during the period. In these, 542 men and 1179 women trainees have participated.

FLD Rice - Krishi Vigyan Kendra – Alleppey, CPCRI (RS) is conducting a Front Line Demonstration on "Integrated Nutrient and Pest Management for improving yield and profitability in Rice" funded by Planning board, Govt of Kerala, implemented through Director of extension, KAU, Thrissur. The FLD is being conducted in an area of 50 hectares consisting of 113 farm families.

On Farm Testing / Frontline Demonstrations

OFT

1. Evaluating performance of IISR ginger varieties for intercropping in coconut gardens
2. Management of stunted growth in cross bred calves
3. Management of feeding problems in dairy animals by substituting low cost feed ingredients
4. Effect of *Trichoderma* against Stem bleeding of coconut
5. Virgin coconut oil production by using different methods
6. Pod borer management in vegetable cowpea using botanicals
7. Evaluation of drudgery reduction for farm women groups engaged in banana plant protection practices

FLD

1. Drought management practices in coconut gardens
2. Demonstration of integrated duck and fish farming
3. Demonstration of leaf spot management in betel vine for better growth and yield
4. Demonstration of proper utilization of coconut palm waste for Oyster mushroom production and income generation
5. Demonstration on mango fruit fly management using ME traps
6. Demonstration on better management practices to improve stingless bee keeping in homesteads
7. Demonstration of value addition of quail egg
8. Demonstration of leaf spot management in banana for better growth and yield
9. Vegetables as intercrop in banana for increasing income
10. Integrated nutrient management for increasing productivity in paddy cultivation

Success stories

Mixed farming by Mr. Babu, a farmer of Alleppey District, who has about 5 acres of land in which the coconut is the predominant crop. Other crops such as banana, vegetables, mango, jack were also planted as intercrops / mixed crops.

Fig. 28. Mixed farming unit of Mr. Babu

Another model farmer, who is a master farmer in mushroom cultivation techniques, Mr. Nazer, is an enthusiastic farmer who realized and utilized the potential for mushroom cultivation in the Alleppey town area.

ALL INDIA COORDINATED RESEARCH PROJECT ON PALMS

The XVIII[th] Biennial Workshop of All India Coordinated Research Project on Palms was held during November 27-29, 2007 at the Main Campus of Acharya N.G. Ranga Agricultural University, Hyderabad. The Workshop was attended by 75 delegates including Dr. H.P. Singh, Deputy Director General (Hort), ICAR, Dr. K.V. Ramana, Asst. Director General (Hort.II), ICAR, Scientists from State Agricultural Universities, AICRP on Palms and Central Institutes.

1. Coconut varieties/hybrids recommended for release from AICRP Centres

Sl. No.	Coconut Variety/ hybrid	Accession number	Institute/ University responsible for release	Regions for which recommended
1.	Kalyani Coconut-1	IND 031 S	BCKV, Kalyani	Rainfed and irrigated areas of West Bengal
2.	Gauthami Ganga	IND 003 S	ANGRAU, Hyderabad	Coastal zone of Andhra Pradesh
3.	Konkan Bhatye Coconut Hybrid-1	IND 003 S x IND127 S	BSKKV, Dapoli	Irrigated areas of Konkan coastal zone of Maharashtra State
4.	Kahikuchi Coconut Hybrid -1	IND 058 S x IND 069 S	AAU, Guwahati	Irrigated areas of Assam State
5.	Coconut Selection-9 CCS-9	IND 069 S	AICRP Palms, CPCRI, Kasaragod	Rainfed and irrigated areas of Kerala, Tamil Nadu and West Bengal States. Comes up well in different types of soil including sandy, sandy loam and red sandy loam with pH ranging from 6.0 to 8.0.

The following recommendations were approved for commercial adoption in the respective region.

2. Crop management technologies for coconut and oil palm

1. Depending on the irrigation water potential available in the coconut gardens of *maidan* tract of Karnataka, the following intercrops are recommended for cultivation in coconut gardens;
   - Coconut – banana (High water requirement)
   - Coconut – annual drumstick (Medium water requirement)
   - Coconut – red gram (Low water requirement)
2. Coconut based cropping system comprising of coconut - black pepper - pineapple is recommended for West Bengal State.

3. Integrated nutrient management packages are recommended for coconut varieties in different regions

- In interior Tamil Nadu region, 100 % N requirement for coconut crop could be supplied through composted coir pith and the balance requirement of P&K could be applied as chemical fertilzers.
- In coastal Andhra Pradesh region, 50 % N requirement for coconut crop could be supplied through composted coir pith and the balance requirement of N, P&K could be applied as chemical fertilzers.
- In *Maidan* tract of Karnataka State, 100 % N requirement for coconut crop could be supplied through composted coir pith and the balance requirement of P&K could be applied as chemical fertilzers.
- In irrigated coconut gardens in Orissa State, 50 % N requirement for coconut crop could

be supplied through composted coir pith and the balance requirement of N, P&K could be applied as chemical fertilzers.

- For organic coconut production in Konkan region of Maharashtra, application of vermicompost (prepared from coconut leaves and other available biomass) @ 50kg per bearing coconut palm during the last week of May or first week of June by basin method is recommended.
- In coastal Tamil Nadu region, 50 % N requirement for coconut crop could be supplied through composted coir pith and the balance requirement of N, P&K could be applied as chemical fertilzers.

4. Integrated nutrient management packages are recommended for the cultivation of hybrid coconut in different regions

- A fertilizer dose of 1000:250:1000 gram NPK / palm / year is recommended for the cultivation of Dwarf x Tall coconut hybrids in interior Tamil Nadu region. 50% of the recommended nitrogen dose could be applied as organic manures and the balance NPK could be applied as chemical fertilizers.
- A fertilizer dose of 500:500:2000 gram NPK / palm / year is recommended for the cultivation of Dwarf x Tall coconut hybrids in irrigated coconut gardens in Assam State. 50% of the recommended nitrogen dose could be applied as organic manures and the balance NPK could be applied as chemical fertilizers.
- A fertilizer dose of 1000:500:1000 gram NPK / palm / year is recommended for the cultivation of Dwarf x Tall coconut hybrids in irrigated coconut gardens in the new Alluvial Zone of West Bengal State. 50% of the recommended nitrogen dose could be applied as organic manures and the balance NPK could be applied as chemical fertilizers.
- A fertilizer dose of 1000:500:2000 gram NPK / palm / year is recommended for the cultivation of Dwarf x Tall coconut hybrids in Konkan coastal region of Maharashtra State. 50% of the recommended nitrogen dose could be applied as vermicompost and the balance NPK could be applied as chemical fertilizers.

5. Fertilizer schedules are recommended for oil palm cultivation in different regions

- Coastal Tamil Nadu region : 1200: 600: 2700 gram NPK / palm / year
- Thungabadhra Command area of Karnataka State : 1200: 600: 1200 gram NPK / palm / year
- Konkan coastal region in Maharashtra State: 1200: 600: 2700 gram NPK / palm / year
- Coastal Andhra Pradesh region: 1200:600: 2700 gram NPK / palm / year

6. Integrated Disease Management package for basal stem rot disease in coconut

- The diseased part of the garden should be isolated from healthy area by digging isolation trench (1 m deep and 0.5 m width). Injury or damage to roots and pruning or cutting of roots should be avoided to prevent infection through injured roots.
- Removal and burning of diseased and dead palms along with roots is recommended. The pit for replanting should be filled up with a mixture of soil and farmyard manure in equal quantities along with 50 g of *Trichoderma viride* talc powder + 1 kg neem cake.
- Talc formulation of *Trichoderma viride* (50 g) in combination with 5 kg neem cake / palm / year should be applied to all palms in a garden where diseased palms are noticed. Even if one diseased palm is noticed in a garden, talc formulation of *T. viride* (50 g) in combination with neem cake (5 kg) per

palm/year should be imposed to all the palms in the garden.

- Frequent watering/irrigation should be done during summer months. While irrigating, care should be taken to avoid flow of water from diseased palms to others. Basin system of irrigation to individual palms should be adopted.

7. Management of stem bleeding disease in coconut

Smearing of talc powder paste formulation of *Trichoderma viride* on the bleeding patches on the stem is recommended. Paste formulation can be prepared by adding 25 ml of water to 50 g of talc powder formulation of *Trichoderma viride*.

8. Leaf blight disease management in Tamil Nadu

Root feeding with carbendazim 2% @ 100ml/palm at quarterly interval is recommended to manage leaf blight disease in coconut in interior Tamil Nadu region.

9. Red gram as indicator plant for basal stem rot (*Ganoderma* wilt) disease in coconut

Red gram plant is a good indicator plant for early diagnosis of basal stem rot disease prone coconut gardens. In *Ganoderma* prone areas, red gram shows bark splitting symptom within a period of three months. Red gram could be raised in basins of coconut in *Ganoderma* prone/suspected soils and immediately after observing the symptoms on red gram, the recommended integrated disease management package against basal stem rot disease in coconut is to be adopted.

10. Cross infectivity nature of *Phytophthora palmivora*, bud rot pathogen of coconut

Phytophthora palmivora, bud rot pathogen in coconut is found to infect coconut, oil palm and palmyrah. Hence, care should be taken that while taking management practices against bud rot in coconut, the palmyrah palms existing in coconut gardens may also be treated as the primary source of inoculum of *Phytophthora palmivora* is found to be from palmyrah palms existing in coconut gardens.