Proceedings of International Meeting on

# ASIA PACIFIC COCOA BREEDERS' WORKING GROUP (APCBWG)

**20-25 May 2019**

**ICAR-CPCRI, Kasaragod, India**


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Proceedings of International Meeting on Asia Pacific Cocoa Breeders' Working Group (APCBWG) , 20-25 May, 2019, ICAR-CPCRI, Kasaragod, p. 42.

Published by

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December, 2019

Printed at

M/s Diganta Mudrana Ltd., Yeyyadi, Mangaluru - 574008

# PREFACE

Cocoa is a profitable plantation crop, amenable for mixed cropping in palm based cropping systems of Asia Pacific region. World demand for chocolate is increasing steadily with an annual growth rate of over 10%. The current demand of cocoa beans for Indian chocolate industry is 40,000 t against the production of 18,000 t. The Indian cocoa sector thus provides ample scope for enhancing production, productivity, and quality of beans.

ICAR-Central Plantation Crops Research Institute- CPCRI initiated cocoa research in 1960's at its Regional Station, Vittal, Karnataka. Fifty five years of cocoa research has culminated in development of high yielding varieties, cropping system models, canopy architecture techniques, advanced cultivation and post harvest technologies for the improvement of cocoa. With Directorate of Cashewnut and Cocoa Development (DCCD) under Ministry of Agriculture & Farmers Welfare, Govt. of India as developmental agency and CAMPCO as a co-operative offering procurement and processing facilities, Indian cocoa sector is systematically laid out in the public sector and also by the private sector Cadbury (Mondelez) in regional research. The huge demand for cocoa in the National as well as the International chocolate industry necessitates further encouragement of cocoa cultivation in traditional zones as well as the non- traditional zones. Realizing the scope to reorient the research, extension and development activities for the sustainable development of cocoa sector in the Asia Pacific region, which is having common production problems the Asia-Pacific Cocoa Breeders Working Group Meeting was organized at ICAR-CPCRI during 20-25 May 2019 with the following objectives.

- To evaluate critically the strength and weakness of cocoa sector in the Asia-Pacific countries.
- To discuss and develop action plans to manage existing as well as emerging pests and diseases of cocoa in the region, especially from climate change perspectives.
- To review the collaborative evaluation trials in the region and to initiate trials in India

Delegates from eight countries participated in the Workshop. Deliberations were made in six technical sessions that are compiled in this proceedings along with recommendations.

Here we place on record our deep felt thanks to Dr. Trilochan Mohapatra, Secretary (DARE) & DG (ICAR), Dr. A. K. Singh, DDG (Hort. Sci.) (ICAR) and Dr. W. S. Dhillon, ADG (Hort.) (ICAR) for their support and guidance for conducting this programme. Large number of foreign delegates could participate in the Group Meeting with the timely support from Ministry of Home Affairs and Ministry of External Affairs. We acknowledge the financial assistance received from MARS, Directorate of Casehwnut and Cocoa Development and CAMPCO. Last but not lease we thank staff members of ICAR-CPCRI who helped directly or indirectly to conduct the programme.

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# AN OVERVIEW ON THE DIRECTORATE OF CASHEWNUT & COCOA DEVELOPMENT (DCCD)

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The Directorate of Cashewnut and Cocoa Development (DCCD) is a national agency established in 1966 primarily engaged in the overall development of Cashew and Cocoa in India. Cocoa Development started in 1997. With regard to cocoa, the mandates are: Formulation and implementation of development programmes; Promote new planting and replanting in potential areas; Coordinate the activities of central and state institutes with the Ministry; Monitoring the development programmes under National Horticulture Mission (NHM); Advisory body to recommend, watch and monitor the various aspects of crop development, marketing and by product utilization; Function as data bank on crop area, production, price trends, marketing and trade performance; Take up intensive publicity measures for dissemination of technologies among farmers; and Impart technical advice to farmers, entrepreneurs on all aspects of cultivation and processing. The major milestones achieved by this Directorate on cocoa development are: New area of 49,000 ha brought under cocoa cultivation; established 265 cocoa demonstration plots; intensive transfer of technology (TOT) activities conducted; 1200 ha senile plantations replanted with high yielding varieties; cocoa nurseries established for quality planting materials in collaboration with CPCRI and KAU; and area under cocoa increased to 78,000 ha from 12,402 ha in 1997-98. Several schemes are under operation by the Directorate through Mission for Integrated Development of Horticulture (MIDH) for Cocoa such as new plantation development, replanting of senile plantations with high yielding varieties, technology dissemination through Front Line Technology Demonstration (FLTD), production of planting materials, and publicity for crop promotion including non-traditional areas and NE States. It is also involved in human resource development, accreditation of nurseries, establishment of model nurseries etc. In collaboration with Agriculture Skill Council of India (ASCI), National Skill Development Corporation (NSDC) skill development program for cocoa nursery worker is taken as a new venture.

# AN OVERVIEW ON THE CENTRAL ARECANUT AND COCOA MARKETING AND PROCESSING CO-OPERATIVE LTD. (CAMPCO)

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The Central Arecanut and Cocoa Marketing and Processing Co-operative Ltd. (CAMPCO) is registered under the multi state co-operative societies Act and operating in areas of Karnataka and Kerala states for membership; there is no area-limit for marketing. It was registered in the year 1973 and came into operation within four months and having a membership of 1,09,147 growers and 160 branches all over India. The main objectives are: Procurement, processing, marketing of products of Arecanut, Cocoa, Rubber and Pepper from members and if necessary, from other growers on agency basis or on outright purchase basis; to arrange for sale of of these crop products to the best advantage of the members and also to advance loans to members on the pledge of goods. Cocoa Procurement and Processing started during 1979 and CAMPCO Chocolate Factory at Puttur was established in 1986. When there was a glut in the market and the procurement was withdrawn by private industries, CAMPCO came into existence to rescue the cocoa farmers. It opened up procurement centres, collected wet beans, processed and produced value added products in its own factory. The factory is equipped with fully automatic and sophisticated machineries with annual licensed capacity of 22000 M.T. The total investment of the factory is around Rs.78.95 crores out of which the funds invested in the machinery is Rs.59.75 crores. The factory manufactures; Cocoa Mass, Cocoa Butter and Cocoa Powder -Industrial Products for internal & export market, Moulded Chocolates, Enrobed Chocolates, Chocolate Eclairs, Sugar Coated Chocolate buttons and Instantised Drinking Chocolate – finished products for internal market & having export potential. CAMPCO has recently exported instant milk flavouring beverage products and Chocolate Eclairs to Australia. Export of cocoa butter to European countries also takes the cue. Salient features of the chocolate factory are: it is the largest in South East Asia, most modern and equipped with machineries imported from five firms of four European countries, equipped with services installed by the best firms of India, well-experienced architects and consultants designed the factory, completed in a record time, situated in an industrially backward rural area in the midst of cocoa cultivation area. CAMPCO Ltd. earns foreign exchange. Being a co-operative venture, this factory provides an opportunity to other co-operative movements by bringing in the dispersed marginal and small cocoa growers under one umbrella. Quality of product manufactured is of international standards. Further developments made are: Installation of Chocolate Mixing Plant from Italy; Vapour Absorption Machine (VAM) for less electricity consumption; Tie-up arrangements with Lotte India Ltd., KMF, Milma, Saanchi, MP, and Defence department; Exporting drinking chocolate to Africa; Obtaining certifications such as FSSC 22000 (Food Safety Management System), ISO 14000 (Environmental Management System) and OHSAS 18000 (Occupational Health & Safety Assessment Series); Installation of Wind Mill to produce 30 lakh units of pollution free green energy; Signed agreement with M/S. Nestle India Ltd.; Taking up mobile procurement unit; and Initiating research and development activities.

# CACAO IMPROVEMENT PROGRAMS AND ACHIEVEMENTS OF CPCRI

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Cocoa (*Theobroma cacao* L.) is a beverage crop of the world, next only to tea and coffee, has become an important plantation crop of India. It is an integral part of palm based cropping systems which effectively utilised the land, air and root space available in arecanut/coconut and oil palm gardens of South India. Five decades of cocoa research at ICAR-CPCRI has paved way for identification of potential clones and development of high yielding varieties suitable for different agro climatic conditions and tolerant to both biotic and abiotic stresses. The improvement strategies followed are; collection and conservation of cocoa germplasm in field gene bank, cataloguing and characterisation of collections with morphological traits, biochemical parameters and molecular tools, establishment of alternative gene banks in different agroclimatic zones for safety duplication, evaluation of clones for adaptability, precocity, stability, compatibility, productivity in the introduced environment, selection breeding and hybridization to develop potential clones, vegetative multiplication and establishment of clonal orchards, quality planting material production with enriched potting mixtures, comparative yield trials (CYT) of elite clones under different cropping systems and spacing, multi location trials (MLT) in traditional and non-traditional zones, quality improvement through modified fermentation techniques, biotechnological and bioinformatics approaches and establishment of demonstration plots in regional institutes and farmers gardens. CPCRI RS Vittal is conserving 515 germplasm collections and 50 hybrids both under arecanut and coconut gardens. Five hybrids have been released viz., VTLCH 1 to 5 and 3 clones VTLCS 1, 2 and VTLCC 1 and recommended for cultivation in Karnataka, Kerala, Tamil Nadu and Andhra Pradesh, Maharashtra, Goa and NE states. Soft wood grafting is standardised and CocoaProBio, a microbial culture, was developed to ensure the health and vigour of seedlings. Hi-tech green house was established to enhance the production of quality planting material. Screening of germplasm for *Phytophthora* pod rot and tea mosquito bug were taken up with different gradings of infection during monsoon and summer seasons respectively. Drought tolerance studies were systematically initiated and intensified with field screening with morpho- physiological parameters and pot culture experiments and physiological thresholds were developed. EST-based databases were developed utilising the genomic resources. New trials were initiated for development of drought tolerant root stocks on climate change perspectives and shade tolerant clones for oil palm gardens. Efforts are underway for development of DUS testing criteria for cocoa in validation with UPOV/ Bioversity guidelines.

# MARS REGIONAL CACAO RESEARCH COLLABORATIONS

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Since 2004 Mars Inc. is supporting the activities of the Asia/Pac Regional INGENIC cocoa breeders group, mainly by organizing annual meetings of all participating countries that are Indonesia, Malaysia, Papua New Guinea, the Philippines, Vietnam and India,. This has allowed the participating countries to develop an interesting best hybrid seed exchange project with each country producing hybrid seeds of three best crosses from their country and send 200 seeds of each cross to all of other participating countries. Over 12,000 hybrid seeds were exchanged in the region in the frame of this collaboration. This way, the best genes in the region for high productivity and resistance to pest and diseases were well distributed over the region. Additionally, with Mars intervention, regional breeders (except India that could not accept it) also had a financial support from World Cocoa Foundation for field testing of all these received hybrids trees issued from received seeds. Several very promising clones were selected from exchanged hybrids. Locations for annual meetings were also chosen the way to coincide with a major cocoa event in the region, like International Cocoa Research Conference, Malaysian Cocoa Conference, Vietnam Cocoa Conference, etc., that allowed regional cocoa breeders to participate to these cocoa research events that otherwise would not be able to attend.

Besides regional breeders, MARS has also supported since 2012 meeting of regional cocoa scientists working with Integrated Pest Management (IPM) with larger meetings attending at least 50 scientists from the region. Four Regional IPM meetings were organized and the largest was in 2015 in Philippines with 120 participants. These meeting specially brought together regional IPM scientists who are anyway working on local pest and diseases like, cocoa pod borer, VSD and *Phytophthora* pod rot, in the frame of their research institutions, but these meeting were very valuable occasion to discuss results of their research, get new ideas and network. The last IPM meeting was specially for discussing the regional project on feasibility of Sterile Males Technique for controlling cocoa pod borer (CPB) and artificial diet as a critical condition for the utilization of this technique to control CPB. A regional project is initiated which is led by Malaysia in collaboration with the International Agency for Nuclear Energy with participation of Indonesia, Philippines and PNG.

Mars also supported some bilateral collaborations with regional national cocoa research institutes in the area of breeding that include field testing of local clonal selections in the Vietnam and Philippines; and breeding program at Mars Cocoa Research Center in Sulawesi with participation of Indonesian Cocoa Research Institute.

# MARS CACAO GENETICS AND BREEDING PROGRAM

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Mars launched its Cocoa for Generations strategy in 2018. The strategy consists of two main pillars: Responsible Cocoa Today and Sustainable Cocoa Tomorrow. Mars plant science research supports the goal of more productive, resilient and profitable cocoa that improves the livelihoods of the farmers and reduces negative impacts on the environment. One of the main strategies is the development of new generation clones through genetics and applied breeding. The Mars genetics and breeding team is mostly based at two main sites: the USDA Research Station in Miami and a new hub at Davis, CA that includes a new greenhouse on the University of California campus, and an office and laboratory near the campus. Applied breeding is conducted at research farms in Brazil, Ecuador and Indonesia. Cacao farmers produce less than 20% of the output they could achieve under perfect conditions with best practices. MARS believes that its research efforts can help to boost the productivity of cocoa farmers we depend on; further encouraging greater funding into cacao research and making the research available unrestricted in the public domain.

# STATUS REPORT OF CACAO RESEARCH IN THE PHILIPPINES

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Cacao industry has been gaining importance in the domestic and export markets as the supply and demand gap of cocoa bean is increasing. Estimated cacao production area in the Philippines reached up to 30,000 hectares in 2017 with an estimated volume of production of 15,000 metric tons. Our target of production in 2022 is to plant 70,000 or more hectares of cacao and so that we get the targeted volume of production of 100,000 MT in order to supply our local demands and export market. To support this target, several financial aids has been provided by different government and non-government organizations, and funding to research institution, academic and private agencies. At University of Southern Mindanao (USM), a leading University in cocoa research in the Philippines, we are presently conducting research on the collection, evaluation and maintenance of cacao clones, and hybrids in our gene bank. These includes: 1. Collection of flavoured cacao (Heirloom cacao known for flavor and aroma); 2. Progeny trial of cocoa hybrids from countries like Malaysia, Indonesia, PNG and Vietnam; 3. Clonal evaluation of best cacao hybrids; and 4. Maintenance and preliminary evaluation of cacao clones from ICQC, UK. Other studies are DNA finger printing and validation in the cocoa nursery and genomic and molecular studies. PCAARRD of the Department of Science and Technology funded big project on 11 research programmes and projects conducted in different parts of the Philippines. These projects are 1. Nursery management for HYVs; 2. Rehabilitation of unproductive plantation through improved Integrated crop management practices; 3. Biocontrol agents for management of cacao pests and diseases; 4. Demo-farm plantation for cacao HYVs (UF18 and BR25); 5. Map cacao production areas; 6. Genome sequencing; 7. Multilocation Trial of 10 promising varieties of cacao in different agro-climatic zone in the Philippines; 8. Development of computer-assisted software for species-site compatibility and site matching function for cacao; 9. Development of sensor devices for quality cacao bean, pod, and husk as fuel briquettes; 10. Capacity building for young researchers in the Philippines. While there are number of researches conducted, the industry still sees the need to conduct further research and development activities. The need for an effective system to promote research products and ensure firm-level technological absorption or facilitate technology transfer must also be taken into consideration. The establishment of a Cacao Research Center is being pushed by industry players in order to have a focal center for R&D and depository of all cacao researches.

# CACAO BREEDING PROGRAM, STRATEGIES AND ACTIVITIES AT MALAYSIAN COCOA BOARD (MCB)

***Haya Ramba***, *Nuraziawati Mat Yazik, Aizat Japar, Zailaini Mohd. Jamil, Mohd. Jaafar Hussin, Mohd. Qahar Muzakkar Mohd. Amin, Sarinah Abu Samah and Mohd. Faizal Acho*

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The establishment of cocoa breeding programme in Malaysian Cocoa Board (MCB) gives an impetus to research on cacao as one of the major crops in Malaysia. So far, MCB has successfully conserved more than 2000 cacao accessions in the germplasm with most of the collections gathered from Reading University of UK, CIRAD, Montpellier, France and United States Department of Agriculture at Miami, Mayaguez & Puerto Rico, International Cocoa Germplasm Genebank, Trinidad, USDA, London Cocoa Trade and others. The basis of scientific research behind breeding programme is to produce and develop clones derived from selection of the best trees which would be reproduced as cuttings. The selection criteria emphasize on high productivity, resistance to pest and diseases and good flavor of beans. The clone selections are subjected to evaluation under various locations and the performance of the clones under variability existing in cultivated fields for various traits are recorded. Currently, MCB has released fourteen clones for commercial plantings (MCBC1 – MCBC14). Continuity and sustainability of the breeding activities are of utmost importance to ensure the availability of sufficient resources for adequate progress in cocoa breeding. Other strategies and activities undertaken by the MCB include stock and scion studies, sexual compatibility, genetic studies, comparative yield trial and inter-specific hybridization.

## REGIONAL CACAO BREEDING TRIAL IN MALAYSIA

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Field trial plots have been established in Malaysian Cocoa Board to evaluate the progenies and clones that were received from Malaysia, Indonesia, Papua New Guinea, Philippines and Vietnam. The trial plots were located at MCB Cocoa Research and Development Centre in Madai, Sabah and BaganDatuk in Peninsular Malaysia. The objective of the trial was to produce new hybrids population which possess high degree of tolerant to Cocoa Pod Borer (CPB) and have good yield as well as bean characteristics. Six progenies from Malaysia, two progenies from Philippines, three progenies from Indonesia, three progenies from Papua New Guinea (PNG) and six clones from Vietnam were evaluated in these plots against two control progenies (UIT1 X NA33 and PA138 X SCA9). These progenies have been evaluated for their performance under that particular condition. More than hundred individual trees have been selected as potential planting materials based on agronomic characteristics, pest and disease assessments and others.

# QTL MAPPING AND IDENTIFICATION OF SNP-HAPLOTYPES AFFECTING YIELD COMPONENTS OF *THEOBROMA CACAO* L.

Luciel dos Santos Fernandes, Fábio M. Correa, Keith Talbert Ingram, Alex-Alan Furtado de Almeida, and **Stefan Royaert**
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Cacao is a crop of global relevance that faces constant demands for improved bean yield. Little is known about the genomic regions or the genes that control yield and bean filling, genes involved in the transport of carbohydrates and in the synthesis of lipids during bean filling. These genes may act during different stages of the reproductive and growth phases like initial fertilization, pod set, cherelle wilt, bean filling during development, seed germination, etc. Such genes might be crucial to the processes involved in photoassimilate fluxes from source-to-sink organs. So, it is important to map QTL regions associated with cacao yield components. The eighteen-year old MP-01 mapping population, a cross between TSH 1188 and CCN 51 was used for this study. About 459 trees genotyped with 6,000 SNPs, genetic map created with 3,526 SNP markers, 12 years yield data from Jan 2007 to Sept 2018 were compared. Best linear unbiased predictions (BLUP) for QTL mapping and Phased SNP haplotype data to identify the favorable haplotype-phenotype associations between yield and related variables were used. Identification of potential candidate genes were done with the use of recombinants to delimit genomic regions from the genome resources of Matina1-6 and B97-61/B2 genome. Broad sense heritability of cocoa yield components, number of total pods harvested, number of healthy pods harvested, single dry bean weight, pod index and average dry bean yield were assessed.

All variables showed considerable phenotypic variation and had moderate to high heritability values. 23 QTLs on 8 chromosomes (LOD 3.11–37.59%, Exp 11.10–23.60) were obtained. Haplotype analysis at the significant QTL region on chromosome IV pointed to the alleles from the maternal parent, TSH1188, as the ones that affect the cacao yield components the most. Haplotype T1 (AAG, from SCA 6) associated with an increase in dry bean weight. Haplotype T2 (GGA, from IMC 67) associated with an increase in the number of pods and higher yield. The recombination events identified within these QTL regions allowed us to identify candidate genes that may take part in the different steps of pod growth and bean filling. Such candidate genes seem to play a significant role in the source-to-sink transport of sugars and amino acids, and lipid metabolism, such as fatty acid production. In future, candidate gene expression analysis in pods and beans at different stages of development for the different haplotype combinations may be taken up, which will help in screening the available germplasm collections with identified SNPs to select potential high-yielding cacao varieties through marker-assisted selection.

# AN OVERVIEW OF CACAO IMPROVEMENT IN PAPUA NEW GUINEA: ATTEMPTS, LESSONS AND ACHIEVEMENTS

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Cocoa is an important export commodity cash crop in Papua New Guinea fetching close to USD 200 million in export revenue for the country. It is the third most important commodity crop after Oil Palm and Coffee supporting about one third (1/3) of the country's population. Cocoa has been in Papua New Guinea for well over 100 years and has become an important lifestyle activity for many rural smallholder farmers who contribute more than 95% of the total production. Trinitario cocoa was first introduced into Papua New Guinea at the beginning of the $20^{th}$ century by German planters who intercropped with coconut in large plantation estates. After large Trinitario cocoa plantations were destroyed by VSD epidemics in the 1960s the Upper Amazonia germplasm was introduced mainly as a source of resistance to the disease.

Genetic Improvement of Cocoa in Papua New Guinea in the past and in recent years has been limited to Trinitario and Upper Amazonian germplasm. The hybrid vigour expressed in crosses between the Trinitario and Upper Amazonia germplasm has been the major source of hybridization and cloning. Traditionally, attempts to develop improved cocoa varieties have been directed at; improved yield potential, agronomic characteristics, quality attributes, pest/disease resistance and ecological adaptability as the major selection criteria. Selected improved cocoa varieties are released based on collective effort from various research disciplines working collaboratively. Adaptive research activities are also being tested/implemented to complement new research technologies developed. Since the 1980s two sets of improved hybrid varieties (SG1 and SG2) and two series of clones (HC-Series 1 and HC-Series 2) have been released to farmers in Papua New Guinea. Whilst the country appreciates the narrow genetic base that it operates with, significant attempts are being made to widen the genetic base through introduction of new germplasm from outside, collection of local germplasm (Trinitario) and population improvement/enhancement.

# VIETNAM COCOA OVERVIEW

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*Cocoa Physiologist, Nong Lam University*

Cocoa was introduced by French into Vietnam in 1890s. Unlike other introduced crops such as rubber and coffee, cocoa was not really commercialized until recent time. Major production areas of Central highlands (it has a problem of bazaltic soil and strong wind); Mekong Delta (it has alluvium soil and high water table); and South East Regions (it has sandy soil and bazaltic soil, hilly terrains and low water table). During 1960s unidentified seeds of trees were used as planting materials and during 1994 hybrids from Costa Rica UF 613 X Catongo, Pound 12 x Catongo, UF 29 X Catongo, UF 613 X Pound 7, UF 613 x UF 676, UF 613 x UF 29, and UF 676 x UF 29 were used. During 2000, UIT 1 x NA 32, UIT 1 x NA 33, UIT 1 x NA 34, UIT 1 x SCA 12, UIT 2 x SCA 12, PA 156 x IMC 67, IMC 67 x PA 156, IMC 67 x SCA 9, PA 156 x SCA 9, PA 138 x SCA 9, PA 173 x SCA 9, and PA 7 x NA 32 were used. Some of the new hybrids namely PA 7 x NA 32, PA 7 x IMC 47, NA 32 x IMC 60, NA 33 x IMC 60, and NA 32 x PA 7 were used for improving flavor, yield and pests and diseases resistance. Monoculture farming system in highland with plant density of 1100 (3 x 3 m) along with Cassia and Acacea were used as wind break, *Leucaena* and *Crotalaria* were used as a shade trees. In Mekong Delta, farming system of Cocoa under Coconut were followed with plant density of (cocoa) 600 – 800 /ha and coconut 150 – 200/ha. Farming system of Southeast Region was cocoa and cashew nut with plant density of 156 (8 x 8m) in cashew and 730 (between and on cashew rows) in cocoa. Banana, *Crotalaria* and *Leucaena* were cultivated as intercrops with plantation and planting density is 1250 (4 x 2 m). Different fermentation methods were used and the Vietnam standards are 1A, 1B and 1C with different bean counts and other parameters namely moisture content, slaty bean, Moldy bean, broken/insect damage and germinated beans. Bean count is <100 for 1A, <110 for 1B and <120 for 1C. Cocoa development has the following advantages in Vietnam: availability of land, planting technology, market, increasing local processing and consumption, and quality. Some of the disadvantages are crop competition, pests and diseases and extreme environment.

# TECHNOLOGY OF COCOA DEVELOPMENT IN INDONESIA

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Cocoa was introduced in Indonesia by Spaniards in Sulawesi in the year 1560. Cocoa was developed in Java in 1880. The significant increase of cocoa production began at 1910 due to the availability of superior cocoa planting materials. The challenges for developing cocoa in Indonesia, among others, are low productivity, decreasing soil fertility, climate change and bean quality. Technology of cocoa development in Indonesia was developed particularly for increasing superior cocoa planting materials, mass propagation methods, GAP, and transfer of technology to the farmer. Breeding program through individual selection firstly conducted at 1912 and this program produced fine flavor cocoa, DR1, DR2 and DR38 as superior cocoa clones, that produced white bean and categorized as Trinitario group. Cocoa breeding program in 1950-1990 focused on increasing the productivity of fine flavor cocoa and developing bulk cocoa. The development target was to have plantation in Java and Sumatra then broaden to smallholder area in Sulawesi. Cocoa breeding program is now focused on addressing pest and disease problem through resistant planting materials. Breeding strategies used are recurrent selection and participatory breeding. Recommended clones for fine flavor cocoa which is resistant to PPR are ICCRI 01 and ICCRI 02, while for VSD resistant is ICCRI 05 and PNT 16 as promising clone. Recommended clones for bulk cocoa are ICCRI 03, ICCRI 04, Sulawesi 1, Sulawesi 2, Sulawesi 3, ICCRI 07, MCC 01, MCC 02, ICCRI 09, ICCRI 06H and ICCRI 08H. The mass propagation methods of cocoa were developed by somatic embryogenesis, plagiotropic clonal and orthotropic shoot cocoa by micro cutting. Crop production technologies developed include pest and disease control technologies, increasing soil fertility, mitigating climate change, replanting and farm mechanization.

# REGIONAL HYBRID TRIAL OF COCOA IN INDONESIA 2014 – 2019

***Bayu Setyawan***, *Indah Anita Sari, and Agung Wahyu Susilo*

Collaboration between cocoa production countries in South-East Asia (Papua New Guinea, and India - Regional INGENIC) was initiated to strengthen cocoa breeding in Asia – Pacific Region through cocoa genetic materials exchange. This program aimed to speed up getting cocoa superior variety that adapting in each country. In Indonesia, INGENIC Regional hybrids testing started since 2007 and was planted in Indonesian Coffee and Cocoa Research Institute (ICCRI) experimental station, Malang. The hybrids that planted come from crossing between superior clones from Philippines, Malaysia, and Indonesia. The variables observed were tree-performamce, pest and disease resistance, and yield since 2010 and up to 2013. Based on individual selection from hybrid populations, we got some promising clones that propagated using side grafting methods in 2016. Selected clones have been evaluated until 2018 and some potential clones were identified. Besides that, some hybrids selected based on population continued to observe yield potential and pest and disease resistance. Results from hybrids trial until 2018 showed the following potential clones selected from Regional INGENIC hybrids: Ardaciar 10 x KKM 22 individual number 1, 80, 90; and BR 25 x S 5 number 13 and 85. Potential hybrids that are continued to be observed are Ardaciar 10 x KKM 22 and TSH 858 x BR 25. Selected clones and hybrids have good resistance to pod rot and *Helopeltis* sp. and potential production around 1.50 – 2.00 ton/ha/year (assumed population per ha = 1000 trees).

# THREE DECADES OF RESEARCH ON COCOA IN KERALA AGRICULTURAL UNIVERSITY – SUCCESS STORY OF PUBLIC PRIVATE PARTNERSHIP

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Cocoa was introduced to India in early 20th century. Cocoa has now become one of the most reliable sources of income for the livelihood of many small farmers of Kerala. Cocoa breeding programme was initiated in Kerala Agricultural University in 1979 and gained momentum from April 1987 with implementation of Cadbury KAU–Cooperative Cocoa Research Project (CCRP) funded by Cadbury India Pvt. Ltd (now Mondelez International). All agro techniques specific for cocoa cultivation in Kerala condition was standardized under this project. Top working was standardized for rejuvenating old and non-productive trees. Major breeding activities undertaken by Kerala Agricultural University includes germplasm collection, characterization and utilization; selection, hybridization programmes for improving yield; resistance against vascular streak die back disease; high phenol content; high fat content; *Phytophthora* pod rot disease resistance; drought tolerance; tea mosquito tolerance; and inbreeding. As a result of this programme seven superior clones (CCRP1-7) and eight hybrids (CCRP 8-15) showing ample resistance to vascular streak die back diseases were released. CCRP 15 was released through marker assisted selection with complete resistance to VSD. Outstanding self incompatible hybrids with high cross compatibility are carried over to clonal gardens. Hybrid seedlings raised by using pods from this garden are distributed throughout the country in collaboration with Mondelez International. These seedlings now rule cocoa plantations in India. This in turn helped to elevate average yield of cocoa to 2 kg/plant/year. Self compatible parents are used for inbreeding with an objective to produce fully homozygous genotypes. Kerala Agricultural University has succeeded in producing the first ever sixth generation inbred in the world. Also developed prediction models for different yield parameters; protocol for short term and long term storage of synthetic seeds etc.

# ACHIEVEMENTS OF KERALA AGRICULTURAL UNIVERSITY IN VALUE ADDITION OF COCOA

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Cocoa is the only source of chocolate. The quality of finished products depends upon the variety grown, agrotechniques adopted, and environmental conditions during pod development and adoption of correct processing practices. The best quality cocoa produced under the favourable environment with better bean size, pulp content and cocoa butter can become unsuitable for chocolate manufacture due to faulty post harvesting practices. In recent years, understanding the relevance of the value addition and increased returns, farmers are coming forward in a big way to take up primary and secondary processing at farm level. Kerala Agricultural University through its continuous dedicated research on farm level processing since 1979 has provided guidelines for producing better quality of cocoa. Primary processing techniques for 2-50 kg was standardized in KAU and it helps in realizing 10-20% more returns. It is expected that at the end of coming decade, India will emerge as the exporter of cocoa. Export of cocoa is possible only if our cocoa meets International standards. Ultimate care has to be taken through out processing period in order to maintain these qualities. Studies conducted at Kerala Agricultural University indicated the feasibility of taking up secondary processing at farm level with small investment. Thus production of chocolate of acceptable quality at farm level, once thought to be impossible, was made into a reality in the year 2000, as a result of continuous effort and organized research done by Kerala Agricultural University. The low cost technology for converting bean into bar without any chemical or preservative was made available to the common man. All primary and secondary processing operations are women friendly and help to improve standard of living of farm families.

# AN OVERVIEW ON TNAU - CADBURY CACAO RESEARCH PROJECT-RESEARCH ACCOMPLISHMENTS IN TAMIL NADU

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Cocoa was introduced in Courtallam hills, Kallar and Burliar fruit stations, Kolli hills and Anamalai hills of Tamil Nadu adjoining Western Ghats hills and plains in earlier days. Now cocoa is widely being cultivated in coconut gardens of many districts in Tamil Nadu but experiences recurrent drought as severe water deficit prevails during summer months (February to May). To avoid crop loss during such dry spells with soaring temperature and to attain sustainability in cocoa production, it is important to screen the germplasm to identify genotypes which show tolerance to water deficit conditions.

**In Crop improvement programme**, totally, 57 genotypes were collected from CPCRI Regional Station, Vittal for various traits including drought studies which include Nigerian collections, ICS collections, Upper Amazon collections, Wayanad collections and hybrids released by CPCRI Regional Station, Vittal. Based on the morphological, physiological, biochemical and root nutrition content, CCRP3, CCRP4, VTLCH3, VTLCH4, NC-23, NC-25, NC-42 and NC-49 were observed to be drought tolerant. Apart from that half-sib and full-sib hybrids have been developed and evaluated for various traits.

**In crop management programme**, vegetative propagation through cuttings, grafting and budding techniques have been standardized to get homozygous planting materials. Fertigation is one of the most important component which enhances the yield of cocoa and application of 75% RDF (RDF: 100:40:140kg of N, $P_2O_5$ and $K_2O$) as WSF through fertigation recorded the highest number of pods per tree. In addition, soil application of micronutrients @ $FeSO_4$(100 g), $ZnSO_4$ (50 g), $MnSO_4$ (25 g), $CuSO_4$ (25 g) and Borax (10 g) per plant per year during July increased the physiological, yield and quality characters of cocoa.

**Farm waste management** technology to decompose the cocoa wastes like leaf litters and pod husk waste was standardized. Application of *Phanerochaete chrysosporium* improves the decomposition rate and the biochemical parameters like C:N ratio, lignin, cellulose, hemicelluloses and humic acid content

**Studies on management of entomofauna of cocoa** were also done and a total number of 23 species of insect pests and 13 species of natural enemies were documented. In addition, IPM module for sucking pest complex of cocoa was developed at TNAU.

Cocoa research in Tamil Nadu Agricultural University (TNAU) received financial assistance from Cadbury Pvt. Ltd/Kraft Foods/Mondelez Pvt. Ltd during the period 2008 to 2018.

# COCOA SCENARIO IN ANDHRA PRADESH

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Cocoa was introduced in Andhra Pradesh during late 1980's. Since then cocoa is concentrated in coastal areas and mainly grown as intercrop in coconut and oil palm gardens. Due to fluctuating prices of coconut, cocoa has become a major source of sustainable income for the farmers. The average dry bean yield of cocoa grown under coconut is 2.5 to 3 kg/tree/year whereas in oil palm is 1.5 -2 kg/tree/year in the state. In Andhra Pradesh, coconut crop is grown in an area of 1.04 lakh ha and oil palm crop is in 1.55 lakh ha. There is large scope in East Godavari and West Godavari districts to encourage cocoa in the oil palm and coconut gardens that are grown under assured irrigated condition. The Department of Horticulture along with Mondelez India (Pvt.) Ltd was involved in area expansion of cocoa in the state by supplying the Cocoa F1 seedlings to the farmers and also the company purchases dry beans of cocoa from the farmers directly through their purchasing centers established in the districts. The Department of Horticulture as part of area expansion programme is providing assistance for plant material and inputs to the farmers. Area expansion of cocoa was achieved through implementation of various schemes of the Department. To meet the demand of the planting material, Dr.Y.S.R. Horticultural University established cocoa clonal garden at Horticultural Research Station, Vijayarai with released clones and hybrids from CPCRI(RS), Vittal and Cocoa Research Station, KAU. The University also involved in conducting research on various aspects such as fertigation schedule, pruning, flowering behavior in view of climate change, yield and bean quality grown under coconut, oil palm and sole crop etc and also providing technical advice to the farmers through awareness meetings, social media, press etc. Scope for expanding cultivation of cocoa in non-traditional districts of Andhra Pradesh is to be explored.

# COCOA PRODUCTION IN RELATION TO CLIMATE CHANGE

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The tropical plant, cocoa (*Theobroma cacao* L.), is endemic to Amazon basin. Its cultivation has subsequently extended to tropical and subtropical regions of South and Central America, West Africa and Asia-Pacific. The physiological characteristics of cocoa have been fairly well understood through extensive studies. The vegetative and reproductive growth of cocoa is influenced by a complexity of environmental factors. The plants being shade tolerant are generally grown as under-storey crop. With information available on physiology, it is possible to take an analytical approach to increase yield by incorporating them into breeding programmes. Yield is not limited by photosynthesis alone, as other climatic and genetic factors also play important role.

Over the past couple of decades, the global climate change has become a major concern and scientific studies to understand this complex phenomenon is given increasing attention. Cocoa, being perennial in nature, has to face the impact of climate change even during a single generation or in a standing plantation. In India, Ghana, Costa Rica and other countries, the climate models have predicted a likely increase up to 2.0°C by 2050. Hence it is important that the impact of climate change on cocoa is understood well.

Quantification of impact of major climate change parameters such as increased temperature and $CO_2$ can be studied by two approaches. In field experimentations, quantifications are done by growing crops in Open Top Chamber (OTC) or in Free Air Carbon dioxide Enrichment (FACE) and Free Atmospheric Temperature Elevation (FATE) facilities. The other approach is to use well validated simulation models. Simulation models are strong tools which provide opportunity to use various climate change scenarios in combination with different management parameters for analyzing the regional impacts. The climate change is due to multiplicity of factors like changing rainfall patterns, increasing temperatures and $CO_2$ levels, which influence cocoa production. More extreme events in climate variability can also occur in some places making cocoa vulnerable.

In order to fill the gap in knowledge on response under long term exposure at whole plant level to elevated $CO_2$ and temperature, cocoa plants were grown in Open Top Chamber facility, wherein two elevated $CO_2$ levels (550 and 700 µmol $CO_2.mol^{-1}$) and elevated temperature (+2°C above ambient OTC) were maintained apart from the chamber control (ambient temperature and $CO_2$). These seedlings are exposed to above mentioned conditions for 2 years and measurements on photosynthesis and related parameters were done.

Results indicated that the elevated $CO_2$ significantly increased net photosynthetic rates ($P_N$) while the transpiration rates (E) remained almost similar to that in ambient $CO_2$ conditions. As a consequence, the instantaneous water use efficiency ($P_N$/E-WUE) has increased by 51% at 550 µmol $CO_2.mol^{-1}$ and by 112% at 700 µmol $CO_2.mol^{-1}$ as compared to that in chamber control. Even though, a 2$^{o}$C increase in temperature above control chamber temperature caused a slight (~4%) reduction in the $P_N$ rates there was an overall increase in the instantaneous WUE by about 20% indicating the ability of plants to adjust the stomatal conductance in such a way that the they are able to efficiently utilize the water in case of increase in temperature. The chlorophyll transients such as $F_0$, $F_v$, and $F_m$ did not significantly differ due to growing condition. The $F_v/F_m$ was more than 0.8, indicating that plants were not under stress in all the treatments. Results indicate that elevated $CO_2$ may prove to be beneficial for cocoa plantations in climate change scenarios, particularly in view of the fact that cocoa is grown as an intercrop either under palms or as agroforestry systems and mostly are maintained under water-non limiting conditions. In addition to increased physiological water use efficiency in elevated $CO_2$ conditions, there is a need to increase the field level (agronomic) water use efficiency through drip irrigation or fertigation for harnessing the potential benefits due to elevated $CO_2$ and also to avoid or minimize the adverse effects if any, of elevated temperature in future climates in cocoa growing regions. Adaptation to climate change scenarios can be through developing drought tolerant genotypes.

Soil and atmospheric droughts are factors limiting cocoa production. Among plantation crops, cocoa is regarded as one of the most sensitive ones to drought. Drought affects several physiological processes leading to reduction in crop yield. Water potential of leaf is a major quantitative characteristic used to assess water stress. The leaf morphology, water relation-components, stomatal behaviour and biochemical factors were studied in cocoa germplasm collection in India. Data so far available, indicate that thick leaf, higher epicuticular wax content, efficient stomatal closure, higher Fv/Fm ratios and high tissue elasticity were responsible for better adaptation of plants to drought conditions. Based on these characteristics drought tolerant accessions and hybrids have been identified in India. Breeding for drought tolerance is important for regions where recurrent drought occurs and these varieties can be cultivated. The application of chlorophyll fluorescence as a tool to screen cocoa for drought tolerance has also been used. The Fv/Fm ratios were found to be higher in drought tolerant accessions as compared to susceptible ones under field conditions in India. Studies carried out in UK under semi-controlled environmental glass houses showed that the ratio of variable to maximal fluorescence (Fv/Fm) was found to be varying in contrasting cocoa genotypes. Genotypic differences in photosynthesis and related traits were also found. The chlorophyll fluorescence parameters showed variation to increased temperatures. There was variability between genotypes in fruit development and bean quality under these conditions. It is possible that the ability to tolerate drought results from stomatal regulation, thus reducing transpirational water loss.

Mitigation of green house gas emission is one of the important aspects related to climate change. Carbon sequestration by terrestrial biomass is one of the mitigation options used for reduction of GHGs. Cocoa produces considerable biomass. Carbon estimations done on the basis of biomass and carbon percentage in tissue indicate net carbon sequestration by arecanut-cocoa system in India. Cocoa production under shade trees has been reported to be 1 t /ha/year in Costa Rica. The $CO_2$ sequestration increased considerably during the growth of these plants. Positive carbon sequestration estimations in various land use systems in Southern Cameroon including several shaded cocoa based agroforestry systems were reported. High soil organic carbon levels indicate higher sequestration of carbon by soil as well in the system. Temporal changes in soil organic carbon of cocoa- gliricidia agroforests in Indonesia has indicated that it remains fairly stable in different stratum. Agroforestry and plantation crops based systems provide opportunity for carbon sequestration and efforts should be made to include these under clean development mechanism for carbon credits. Thus, it is necessary that development of '*green technologies*', '*adverse climate tolerant varieties*', '*adverse climate proofing*' by breeding, crop diversification, crop intensification and mixed farming need to be promoted for enhancing the resilience to climate change and livelihood of vast majority cocoa farmers around the world.

# PERFORMANCE OF COCOA VARIETIES/ HYBRIDS AS INTERCROP IN COCONUT/ OIL PALM GARDENS IN DIFFERENT REGIONS OF INDIA

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The All India Coordinated Research Project on Palms started functioning from 1972 with the objective of conducting location-specific research in the mandate crops (coconut, oil palm, arecanut, palmyrah and cocoa). The increasing popularity of cocoa in India has necessitated the production of large number of high yielding hybrids and clonal materials with resistance to pest and diseases along with its suitability to different agro-climatic conditions. A field investigation on evaluation of cocoa varieties/ hybrids for their performance as intercrop in coconut gardens was carried out for morphological and yield parameters under AICRP on Palms centres *viz.,* Aliyarnagar and Veppankulam (Tamil Nadu), Kahikuchi (Assam), Ratnagiri (Maharashtra), Ambajipeta (Andhra Pradesh) and Navsari (Gujarat). Six cocoa clones *viz.,*VTLC-1, VTLCC-1, VTLCH-1, VTLCH-2, VTLCH-3 and VTLCH-4 were received from CPCRI (RS), Vittal during 2008-09 and planted at a distance of 3.75 m x 7.5 m in a single hedge system under 7.5 m x 7.5 m spaced, bearing-coconut garden with four replications in a Randomized Block Design. Based on the initial evaluation trials, the cocoa clones VTLCH- 2 recorded 2.1 kg dry beans per tree per year (Ambajipeta, A.P), 1.44 kg dry beans per tree per year (Navsari, Gujrath) and 1.80 kg dry beans per tree per year (Veppankulam, TN) followed by VTLCH-4. In Vijayarai (Andhra Pradesh), 12 cocoa clones and 2 hybrids are being evaluated for growth and yield parameters and to assess their performance as intercrop in oil palm garden since 2012. The number of pods per tree per year did not differ among the clones studied and it ranged from 19.10 to 36.00 respectively. From the present studies, based on growth and yield parameters assessed, it is evident that performance of all the clones of cocoa in terms of yield is on par in the initial years of establishment (six to eight years after planting). However, continuous evaluation needs to be required to assess their yield potential and quality parameters when grown as intercrop in coconut and oil palm gardens for some more years.

# IMPACT OF CLIMATE CHANGE ON COCOA PRODUCTION ACROSS DIFFERENT REGIONS OF INDIA

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Increasing $CO_2$ in atmosphere, high temperature and water deficit stress are found to have profound influence on the growth and yield of cocoa. In this study, future climate scenarios on cocoa production were evaluated for major cocoa growing regions. Seventeen general circulation models (GCMs), under moderate and high representative concentration pathway (RCP) scenarios (4.5 and 8.5) and elevated $CO_2$ [$ECO_2$] concentration, were employed to project the climate for near (2020-2050) and far future (2061-2080) periods. The relation established in an earlier Open Top Chamber (OTC) study between biomass production and increased $CO_2$, high temperature and water deficit stress and their interaction were used to assess the impact under future scenarios with current management practices. For these study regions, the climate models have predicted an increase of 1.49°C and 2.04°C in maximum temperature ($T_{max}$), 1.72°C and 2.22°C in minimum temperature ($T_{min}$), and of 1.59 mm and 5.32 mm in precipitation during fruiting seasons (March-June) for 2021-2050 and 2061-2080 respectively at RCP 4.5. The corresponding increases for RCP 8.5 were 1.92°C and 3.44°C for $T_{max}$, 2.2°C and 3.78°C for $T_{min}$, and 1.16 mm and 4.49 mm for precipitation respectively. For 2021-2050, cocoa yield was projected to increase by 0.6% under RCP 4.5 and decrease by 0.26% under RCP 8.5 compared to the base lined yield. However, for the period 2061-2080, a decreased yield both under RCP 4.5 (0.5%) and RCP 8.5 (3.3%) are predicted. The increased or sustained future climate yield levels in cocoa could be attributed to the fertilization effect of elevated $CO_2$ dominating the detrimental effects of high temperature. The temperature effect was quite harsh in east coast of Godavari belts of Andhra Pradesh and Salem and Erode of Tamil Nadu. Adequate irrigation and proper shade as an understory crop under coconut or oil palm in these regions is found to be the best management practice to alleviate the effects of high temperature in cocoa. Further from this analysis it is observed that Chikmangalur in Karnataka and North Eastern regions are becoming more suitable for cocoa cultivation. These projections suggest that the effect of climate change on cocoa production may be minimal of India.

# COCOA: CROP MANAGEMENT- PRESENT STATUS AND FUTURE CHALLENGES

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Cocoa, a beverage crop having high commercial potential, is mostly grown in India as a mixed crop in arecanut, coconut and oil palm gardens. It is mainly cultivated in four major southern states of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. The cocoa industry in the country has expanded to a considerable extent in recent years, with a production of 15,133 tonnes of cocoa from an area of 7,1335 hectares and contributes about Rs. 2000 million annually to the GDP of the nation. Tamil Nadu has the highest area under cocoa (34%) while in the case of cocoa production; Kerala has the major share (42%). At present, demand for cocoa beans far outstrips the local production, necessitating large scale imports to meet the national requirements. Taking into consideration the present day consumption patterns and growth of confectionery industry in India at around 15%, the demand for cocoa is likely to increase in coming years. As a matter of fact, cocoa for India is a high potential crop with broad positive externalities for the sector as a whole. We are, as of now, a very small player in the international arena, and need to explore the possibilities to make cocoa sector a dynamic and vibrant one.

The projected demand of cocoa by 2050 is 212 thousand tonnes against the estimated supply of 121 thousand tonnes. With the projected supply, there would be a demand supply gap of 90 thousand tonnes of cocoa beans in 2050. To achieve this target, the cocoa production in the country should increase at an annual growth rate of 7.68 per cent considering the market growth at 20% and the cocoa sector has a great potential to develop in future years.

Cocoa in its native zone is grown as an under storey crop either under permanent shade or under temporary shades. In the Asian continent, cocoa cultivation is widely undertaken in palm-based cropping systems. Cocoa, with its typical growth habit of branching in tiers, tends to grow high which is considered as unfavourable in the cropping system models. There are genotypes with erect, intermediate and pendulous branching habits in which intermediates are considered compatible in the inter-cropping systems. Different spacing under arecanut, single and double hedge systems of planting under coconut, triangle system of planting under oil palm are being followed in cocoa cultivation with canopy modifications. Formation pruning and training in young plants, structural and sanitary pruning in matured trees, canopy architectural engineering in both grafted and seedling plants are developed, standardised and are being practiced regularly in cocoa plantations. The challenge is to expand these methods in different cropping systems and agro climatic zones and to maintain optimal canopy area for achieving productive yield of cocoa.

At present, the important production aspects like irrigation and nutrition requirements were worked out for cocoa as an intercrop in arecanut. Suitable nutrient management, irrigation, fertigation and pruning technologies for cocoa in coconut and oil palm plantations need to be developed as nutrition and irrigation schedules for base and intercrops are different. The response of cocoa to irrigation and nutrition under different shade levels needs to investigated to improve input use efficiency and quality of beans especially butter content. Soil conservation measures like mulching with cocoa leaves, fertigation combined with modified manageable canopy architecture will improve the cropping efficiency of cocoa even in adverse situations. In the cropping system, clones are to be grouped, aiming for medium vigour and optimal canopy to get higher pod yield.

The estimated biomass produced by cocoa per ha varied from 8450 kg under arecanut to 13000 kg under coconut. The available recyclable biomass from cocoa that includes pruned biomass, leaf litter and pod husk, is quantified as 0.2 - 0.3 million tonnes annually in India. Cocoa litter fall and application of prunings directly as mulch ensures moisture conservation, weed control and soil fertility improvement. The technology for vermicomposting of recyclable cocoa biomass has already been standardized which produces compost rich in nutrients compared to other manures. However, studies are required on *in situ* vermicomposting of cocoa wastes/prunings in low to medium rainfall regions of Andhra Pradesh, Tamil Nadu and Karnataka for reduced labour requirement. Cocoa pod husk is an important source of potassium. Deficiencies of potassium, zinc and iron are widespread in cocoa growing regions of South India. Development of nutrient formulations specific to different regions is most important to enable easy access of all nutrients at reasonable price to farmers. Management strategies need to be fine tuned to climate change scenario with precise application of inputs as weather variations result in delayed flowering and outbreak of certain pests and diseases.

# PESTS AND DISEASES OF COCOA IN INDIA-STATUS AND STRATAGIES

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Cocoa *(Theobroma cacao* L.) is an exotic crop introduced in India in early 20th century with limited cultivation under the government owned farms. Systematic cultivation of cocoa in India started in 1970s. Both the varieties of "Criollo" and "Forastero" were introduced. However due to its high susceptibility to the different pests and diseases, Criollo variety was slowly replaced with Forastero. Till recently, except *Phytophthora* diseases, not many pests or diseases on cocoa were reported but now the biotic and abiotic constraints have become major limiting factors in cocoa production. Among the biotic stresses, insect-pests, diseases and vertebrate pests like rodents and squirrels are the major ones affecting the production and productivity of cocoa.

Tea mosquito bug (TMB) (*Helopeltis* spp.) has become a major threat for cocoa production in most of the cocoa growing areas. On large-scale conversion of cashew plantation into cocoa, TMB also extended its host range to cocoa and emerged as a major insect-pest over time. Being polyphagous, TMB is quite damaging in cocoa gardens adjoining cashew plantations invariably in all cropping seasons. *Helopeltis bradyi* and *H. theivora* are the predominant species on cocoa. Other than TMB, mealy bug (*Planococcus lilacinus; Ferrisia virgata; Crisicoccus hirsutus*); borer complex (*Rhaphipodus subopacus*; *Euwallacia fornicatus*; *Xyleborus* spp.) and castor capsule borer (*Conogethes punctiferalis*) recently started causing economic damage to cocoa. The present research on insect pest management is focussing on screening of cocoa germplasm against TMB, exploration of bio-control agents of insect pests associated with cocoa ecosystem, isolation, identification, synthesis and evaluation of pheromone components from *H. theivora* and molecular characterization of borer complex associated with cocoa.

Among various diseases, diseases caused by *Phytophthora* mainly black pod disease (BPD), seedling die-back, chupon blight/twig blight and stem canker are prevailing in most of the cocoa growing areas. In India, BPD incidence varies from 12 to 30%, depending upon locality and garden. *Phytophthora palmivora* is the predominant species causing black pod, though other species like *P. capsici* and *P. citrophthora* have been reported earlier. As of now *P. megakarya* is not recorded in India. Regular pruning and prophylactic spray with 1% Bordeaux mixture is recommended for management of black pod disease. Stem canker is another major disease for which *Trichoderma harzianum* based integrated disease management strategies have been developed. Other diseases reported are charcoal pod rot caused by *Lasiodiplodia theobromae,* cherelle wilt caused by *Colletotrichum gloeosporioides,* vascular streak die-back (VSD) caused by *Ceratobasidium theobromae.* VSD is restricted to certain districts of Kerala and not noticed in other states. Though wilt disease caused by *Ceratocytis* is recorded earlier, it is not a major problem at present. Dieback disease caused by *Lasiodiplodia* is an emerging disease recorded in few places in Andhra Pradesh and Kerala. The vertebrate pests like rodent and squirrels are other major limiting factors in cocoa production. Strict quarantine is essential to prevent the entry of other major pests and diseases like cocoa swollen shoot virus, necrosis virus, yellow mosaic virus, frosty pod rot and witches-broom and pod borer etc.

# DEVELOPMENT AND EVALUATION OF COCONUT SUGAR BASED HOME MADE BEAN TO BITE DARK CHOCOLATE

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A complete value chain for on-farm bean to bite dark chocolate production adaptable for cottage level farmers and entrepreneurs was developed at ICAR-CPCRI. The proctocol is consisting of fermentation, drying, roasting and winnowing of cocoa beans, refining of nibs with coconut sugar and cocoa butter, tempering, moulding, refrigeration, demoulding, packaging and storage for the preparation of bean to bar chocolate using coconut sugar. Basket method of fermentation was carried out for 5 days followed by drying in an electric drier at 65±5°C. Optimum roasting time in tray drier was found to be 130 °C for 1 h. Refining time based on the particle size of the chocolate was standardized using light microscope image analysis suggested a minimum refining time of 24 h. Besides, the effect of varying levels of coconut sugar (30-50%), cocoa liquor (35-45%) and cocoa butter (15-25%) on sensory (appearance, mouth feel, texture and taste) and textural proprieties (hardness) of dark chocolate grinded using a chocolate refiner were also studied using Box and Behnken Design under response surface methodology. Significant differences in the model ($p<0.05$) was observed for all the parameters except for appearance and hardness. The optimized combination consisted of 70% dark chocolate using 45% cocoa liquor, 30% coconut sugar and 25% cocoa butter had a maximum desirability of 0.96 for which the predicted sensory score for appearance, mouth feel, texture and taste and textural hardness were 8.14, 7.98, 8.05, 7.55 and 52.14N respectively. Based on the experimental findings, a cottage scale unit for bean to bite dark chocolate production was established at the Agri-Business Incubation Centre of ICAR-CPCRI consisting of a roaster, bean cracker, winnower, refiner, melter, manual tempering set up and refrigeration system.

# COCOA IN INDIA: STATUS, POTENTIAL AND APPROACHES

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Cocoa is grown in 58 countries in around 10 million hectares with an estimated production of 4.0 million tonnes worldwide. Among the major countries, Côte d'Ivoire has the highest productivity of 660 kg/ha, while the world productivity is 504 kg/ha. The four West African countries *viz.*, Côte d'Ivoire, Ghana, Cameroon and Nigeria contributed for 74% of worldwide cocoa production. In the global production scenario, India is a very small player with the production share of meagre 0.31 percent. In India, cocoa is cultivated mainly in the states of Tamil Nadu, Andhra Pradesh, Kerala, and Karnataka. India produced 18,920 tonnes of cocoa from an area of 82,940 hectares with a productivity of 580 kg/ha in the year 2017. Tamil Nadu has the highest area under cocoa (35%), followed by Andhra Pradesh (29%), and in the case of cocoa production, Andhra Pradesh has the major share (41%) followed by Kerala (38%). The contribution of cocoa to the national income amounts to Rs 2000 million. The cocoa industry in the country had expanded to a considerable extent in recent years. At present more than 15 industrial entrepreneurs and firms existing in the field demanding nearly 38,000 tonnes of cocoa beans of which the present domestic availability is only about 42%.

Between 2009 and 2017, world cocoa consumption expanded by 26% with most of the increase coming from higher consumption in the traditional cocoa consuming countries of Europe (up by 16%) while consumption increased by 23% in the Americas over the same period. The most dynamic regions in terms of cocoa consumption were the Asian region (up by 51%) and the African region (up by 75%). Information on net exports of cocoa beans shows that the African region, accounting for 70% of net world exports, is by far the largest supplier of cocoa to the world markets. The cocoa market remains highly concentrated, with the top five countries accounting for 87% of world net exports. Côte d'Ivoire is the world's leading exporter of cocoa beans, representing 28% of global net exports, followed by Nigeria (21%) and Ghana (19%).

Taking into consideration the present day food consumption patterns and growth of confectionary industry in India at around 20%, 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.

The import of cocoa and cocoa products to India has increased at a compound growth rate of 17% during the ten years period (2008-17), which shows a surging domestic demand of cocoa and cocoa products as well as surplus processing capacity existing in the country. On the other hand, the export growth was almost stagnant which accounts for only around nine per cent of total value of exports during the period under consideration. It is noteworthy that the import of cocoa in the year 2017 was 63,613 tonnes, while the export was meagre 25,700 tonnes accounting for a negative trade balance of 37,913 tonnes. Since there is attractive growth rate of the demand for cocoa worldwide, it is pragmatic to put concerted effort to enter into the export sphere of cocoa. The projected demand of cocoa in India by 2050 is 212 thousand tonnes against the estimated supply of 121 thousand tonnes. With the projected supply there would be a demand-supply gap of 90 thousand tonnes of cocoa beans in 2050. To achieve this target the production should increase at an annual growth rate of 7.68%.

We need to chalk out a logical and pragmatic strategy to achieve the desirable projected demand-supply equation. Growth in per capita consumption of cocoa in India is the motivating factor behind the projection of an optimistic supply-demand scenario. We have about 26 lakhs ha area available in India under coconut, arecanut and oil palm gardens for cultivation of cocoa plants (new area expansion) and around 35% of this land is under irrigation. Thereby, the total potential area for cocoa planting comes to around nine lakhs ha. Availability of such areas in the states of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Orissa will therefore offer ample scope for new area expansion of cocoa.

To sum up, cocoa for India is a high potential crop with broad positive externalities for the sector as a whole. We are as of now a very small player in the international arena, and need to explore the possibilities to make our cocoa sector a dynamic and vibrant one. There are potentials and possibilities in the form of massive acreage wherein cocoa can be comfortably accommodated as an inter crop, an internal market with accelerated annul growth of confectionery industry, and a well established research and development back up. On the other hand, there are emerging and evolving hurdles to cross, in the forms of highly fluctuating international prices for the commodity, ever increasing mergers and acquisitions in the cocoa industry, controls exerted by the retail giants and the stringent food safety standards in the international spectrum, lack of high-level technical competence and entrepreneurship in the domestic sector.

# RECOMMENDATIONS

## Cocoa Improvement

- To develop drought tolerant variety, drought tolerant root stocks as well as scions may be evaluated. Uniformity/homogenous nature of drought tolerant root stocks need to be confirmed in drought studies.
- Studies on salinity tolerance in cocoa genotypes may be taken up.
- New crosses with upper and lower Amazon clone s may be initiated.
- Clones/Trinitarios rich in flavour components may be collected and exchanged between countries.
- Possibility of depositing elite clones/hybrids from Asia Pacific countries to Intermediate Quarantine Centre, University of Reading may be explored, so that it can be exchanged easily with other researchers.
- Resistance breeding for *Phytophthora* may be strengthened.
- Use of techniques for long term *in vitro* conservation of core collection of cocoa germplasm
- Development of genomic selection models fro breeding for specific traits such as bean size, disease resistance etc.

## Cocoa Production

- Maintaining the productivity in the traditional belts of Kerala & Karnataka, India with regular, systematic pruning regimes and region specific modified strategies for soil, nutrient and water management in non- traditional belts of Tamil Nadu & Andhra Pradesh states.
- Effective methods for recycling of biomass available in cocoa gardens, the leaves, husk and shell.
- Site specific fertilizer/ nutrient/ PGPR formulations may be developed and validated.
- High density planting systems will be further evaluated under different cropping models.
- Possibility of crop regulation in cocoa may be explored (when grown with multiple fruit crops)
- Remote sensing technology may be used to assess the extent of area under cocoa cultivation.

**Cocoa Protection**

- Development of disease forecasting models and eco friendly management practices.
- Identification and geo mapping of mealy bugs and tea mosquito bugs for development of location specific IPM modules.
- Genes responsible for resistance to major pests and diseases with cocoa genome resources will be identified and expression of genes will be verified.
- Efficient microbial consortia may be developed to manage *Phytophthora* disease of cocoa and utilized for Induced Systemic Resistance.
- Effective strategies to manage mammalian pest to be developed.
- Predators and parasitoids may be identified for management of major pests including tea mosquito bug.
- ICAR- CPCRI, Vittal and ICAR- DCR, Puttur to take collaborative efforts for IPM strategies in controlling tea mosquito bug menace in cocoa and cashew.
- Strengthening bio intensive management of diseases associated with cocoa.

**Cocoa Pre and Post Harvest Technology**

- Refinement of minimal processing techniques to improve the quality of beans and enhancing the farm- level processing facilities.
- Equipment/ machinery may be developed for breaking of pods and increasing work efficiency.
- Driers may be developed for high rainfall zones. Development of integrated dryers (solar, agricultural wastes and electrical based) for drying fermented cocoa beans.
- Possibility for developing community based processing unit in non- traditional areas may be explored.

**Marketing**

- State machinery should go for MoU with the leading chocolate manufacturers for appropriate marketing arrangements and supply chain development.
- Assured buy-back systems developed in the frame of contract farming (tripartite arrangement) can help the growth of the sector.

**Transfer of Technology**

- Participatory research involving farmer groups for refining and fine tuning of technologies for higher efficiency of the sector and developing agri business incubators.
- Empowering women and attracting youth through skill development (nursery/ processing/ chocolate making).

**INGENIC Discussions**

- Addressing problems and obtaining solutions for VSD (vascular streak dieback), BPD (black pod disease), TMB (tea mosquito bug), pod borer, moisture-deficits specific in countries of Asia Pacific region, India, Indonesia, Malaysia, Philippines, Vietnam and Papua New Guinea by continuing regional collaborative programs with new hybrid production and evaluation programs.
- Country specific requirements of MTA's and region specific common MoU's will be looked into for further collaborations and funding from World Cocoa Foundation, Mars Incorp., ICCO etc.
- Along with INGENIC, possible partnership in other research groups INCOPED, pest and disease/ soil management will be explored.

# PROGRAMME

## Inaugural Session (DJ Hall: 20.05.19; 10.00 AM)

| | |
|---|---|
| Welcome address | Dr. Anitha Karun<br>Acting Director, ICAR-Central Plantation Crops Research Institute |
| Introduction of Asia Pacific Cocoa Breeders and the working group initiatives | Dr. Smilja Lambert<br>Cocoa Research Manager (Asia Pacific), MARS |
| Presidential address | Dr. Venkatesh N. Hubballi<br>Director, Directorate of Cashewnut & Cocoa Development |
| Lighting of lamp and inaugural address | Dr. N. Kumar<br>Vice Chancellor, Tamil Nadu Agri. University |
| Felicitations | Mr. Sankar Narayana Bhat<br>Vice President, Central Arecanut & Cocoa Marketing and Processing Cooperative Ltd. |
| | Dr. H. P. Maheshwarappa<br>Project Coordinator, AICRP on Palms |
| | Dr. J. Dilip Babu<br>Director of Research, Dr. YSR Hort. University |
| Vote of Thanks | Dr. S. Elain Apshara<br>Principal Scientist, Central Plantation Crops Research Institute |

## Technical Sessions

**SESSION I: Status Report- Cocoa Research and Development in India (DJ Hall: 20.05.19; 12.00 to 1.30 PM)**

| | |
|---|---|
| Chairman | Dr. N. Kumar, Vice Chancellor, TNAU, Coimbatore |
| Co-Chairman | Dr. Y. Dilip Babu, Director of Research, Dr. YSRHU |
| Conveners | Dr. Niral, Principal Scientist, ICAR-CPCRI |
| | Dr. R. Sudha, Scientist, ICAR-CPCRI |

**SESSION 2: Country-wise Presentations on Cocoa Improvement Programme (DJ Hall: 20.05.19; 2.15 to 5.00 PM)**

| | |
|---|---|
| Chairman | Dr. Romulo L. Cena, Professor VI, Department of Plant Breeding, College of Agriculture and Director of University of Southern Mindanao Agricultural Research Center (USMARC) |

| | |
|---|---|
| Co-Chairman | Dr. Anitha Karun, Acting Director, ICAR-CPCRI |
| Conveners | Dr. S. Elain Apshara, Principal Scientist, ICAR-CPCRI |
| | Ms. T.N. Ranjini, Scientist, ICAR-CPCRI |

**Visit to ICAR-CPCRI Regional Station, Vittal: (Leave Kasaragod on 21.05.19 at 8.30 AM)**

Field Gene Bank, Nursery & Experimental plots on Cocoa (10.00 AM to 1.00 PM)

**SESSION 3: Regional Breeding Activities/INGENIC**

**(ICAR-CPCRI Regional Station Conference Hall: 21.05.19; 2.00 to 5.00 PM)**

| | |
|---|---|
| Chairman | Dr. Haya Ramba, Director of Cocoa Upstream Technology Division, MCB |
| | Dr. D. Balasimha, Formerly Head, ICAR-CPCRI, Regional Station, Vittal |
| Convener | Dr. S. Elain Apshara, Principal Scientist, ICAR-CPCRI |

**Visit to ICAR-CPCRI Research Centre, Kidu: (Leave Kasaragod on 22.05.19 at 8.00 AM)**

| | |
|---|---|
| Convener | Dr. Ganesh Khadke, Scientist, ICAR-CPCRI |

Visit to CAMPCO Chocolate Factory (2.00 to 4.00 PM)

**SESSION 4: Climate change perspectives (DJ Hall: 23.05.19; 09.30 to 11.00 AM)**

| | |
|---|---|
| Chairman | Dr. David Mackill |

Breeding Director MARS Wrigley Confectionary USA

| | |
|---|---|
| Co-chairman | Dr. Ravi Bhat, Head, Crop Production, ICAR-CPCRI |
| Conveners | Dr. Senthil Amudan, Scientist, ICAR-CPCRI |
| | Dr. Nagaraja, N.R., Scientist, ICAR-CPCRI |

**SESSION 5: Regional Cocoa Research & Resistance Breeding Activities**

**(DJ Hall: 23.05.19; 11.30 AM to 1.30 PM)**

| | |
|---|---|
| Chairman | Dr. H.P. Maheshwarappa, Project Co-ordinator |

AICRP on Palms

| | |
|---|---|
| Co-chairman | Dr. T.N. Raviprasad |
| | Principal Scientist, ICAR-DCR, Puttur |
| Conveners | Dr. V.H. Prathibha, Scientist, ICAR-CPCRI |
| | Dr. Shivaji Thube, Scientist, ICAR-CPCRI |

**Visit to Experimental plots (2.30 PM to 5.00 PM)**

**SESSION 6: Processing, Value Addition, Marketing**

**(DJ Hall: 24.05.19; 09.30 AM to 11.00 AM)**

| | |
|---|---|
| Chairman | Dr. K. Muralidharan, Head, Social Sciences, ICAR-CPCRI |
| Co-Chairman | Dr. K.B. Hebbar, Head, Crop Physiology & Post Harvest Technology, ICAR-CPCRI |
| Conveners | Dr. M. Neema, Scientist, ICAR-CPCRI |
| | Dr. R. Pandiselvam, Scientist, ICAR-CPCRI |

| | |
|---|---|
| Agri Business Initiatives | Dr. K. Muralidharan, Head, Social Sciences, ICAR-CPCRI |
| Production physiology, abiotic stress management | Dr. K.B. Hebbar, Head, Crop Physiology & Post-Harvest Technology, ICAR-CPCRI |
| Kalpa dark bean to bar chocolate | Dr. M. R. Manikantan, Principal Scientist, ICAR-CPCRI |
| Home scale chocolate production | Dr. Minimol, Assoc. Professor College of Horticulture, Vellanikkara, Thrissur, Kerala |
| Economical perspectives on cocoa development in India | Dr. S. Jayasekhar, Senior Scientist, ICAR-CPCRI |
| Yield forecasting in cocoa | Dr. K.P. Chandran, Principal Scientist, ICAR-CPCRI |

**VALEDICTORY SESSION (DJ HALL: 11.30 AM to 1.30 PM)**

| | |
|---|---|
| Chairman | Dr. Anitha Karun, Acting Director, ICAR-CPCRI |
| Presentation of report and recommendations | Dr. S. Elain Apshara, Principal Scientist, ICAR-CPCRI |
| Valedictory address | Dr. Thomas John, Plantation Consultant |

# ORGANIZING COMMITTEE

Committee Members for conducting International Meet on Asia Pacific Cocoa Breeders Working Group 20- 25 May 2019

**Organizing Committee**

**Chairman**

Dr. Anitha Karun, Act. Director, ICAR-CPCRI, Kasaragod

**Members**

Dr. K. Muralidharan, AHOD, Social Sciences

Dr. H. P. Maheswarapp, PC (Palms)

Dr. C. T. Jose, Head, ICAR-CPCRI Regional Station, Vittal

Dr. K. B. Hebbar, AHOD, Plant Physio., Biochem, & PHT

Dr. Ravi Bhat, AHOD, Crop Produciton

Dr. Vinayaka Hegde, AHOD, Crop Protection

**Convener**

Dr. S. Elain Apshara, Principal Scientist, ICAR-CPCRI Regional Station, Vittal

**Programme Committee**

**Chairman**

Dr. V. Niral, Principal Scientist

**Members**

Dr. M. R. Manikantan Dr. Sujitra

Mr. G. S. Hareesh

Mrs. Sulochana Nair

**Conveners**

Dr. R. Sudha

Ms. Ranjini, T.N

**Reception Committee**

**Chairman**

Dr. K. P. Chandran

**Members**

Mr. K Shyama Prasad

Mr. K. K. Nair

Mrs. Girija Chandran

Mrs. Sreelatha, K.

**Conveners**

Dr. V.H. Pratibha

Dr. Ajith Singh

**Registration Committee**

**Chairman**

Dr. M.K. Rajesh

**Members**

Mr. Vidyadharan

Dr. K.S. Muralikrishna

Mrs. Chithralekha Kodoth

**Conveners**

Dr. Neema

Dr. Krishna Prakash

**Accommodation Committee**

**Chairman**

Dr. Rajkumar

**Members**

Dr. Shivaji Thube,

Dr. Thava Prakasa Pandian

Dr. Ganesh Kadke,

Mr. Neil Vincer

**Conveners**

Dr. R. Pandi Selvan

Dr. Shameena Beegum

**Transportation Committee**

**Chairman**

Mr. Hareesh Nair

**Members**

Mr. T.E. Janardhanan
Mr. K. R. Nithyanandan
Mr. K. J. Sebastian

**Conveners**

Mr. Sebastian George

**Hospitality Committee**

**Chairman**

Dr. K. Shamsudeen

**Members**

Mr. A. O. Varghese
Mr. K. Krishnan Nair
Mr. K. Raghavan

**Conveners**

Mr. K. Devadas

Mr. V. Balakrishnan

**Hall Arrangement Committee**

**Chairman**

Dr. A.C. Mathew

**Members**

Mr. Ajithkumar K.
Mr. V. K. Gopalakrishnan
Mr. K. Devaraj

**Conveners**

Dr. V. Selvamani
Mr. A. Sadanandan

**Publicity Committee**

**Chairman**

Dr. C. Thamban

**Members**

Mr. H. Muralidrishna
Mr. K. Shobha

**Convener**

Mr. Shyama Prasad

**Finance Committee**

**Chairman**

Dr. K. Muralidharan

**Co-chairman**

Mr. Ramavatar Parasar

**Members**

Dr. S. Jayasekhar
Dr. S. V. Ramesh

**Convener**

Mrs. Reetha M.

**Entertainment Committee**

**Chairman**

Dr. P. S. Pratibha

**Members**

Mrs. M.P. Jayasree
Mrs. K.S. Visalakshi
Mr. Udayakumar
Mr. Rathan Singh

**Convener**

Mr. P. Ravindran

## List of International Delegates

| Sl. No. | Name | Designation, Organization & Address | E-mail | Nationality |
|---|---|---|---|---|
| 1 | Dr. Smilja Lambert | Cocoa Research Manager (Asia/ Pacific)MARS | smilja.lambert @effem.com | Australia |
| 2 | Dr. Etienne Jean Michel Lambert | Agronomist | etiennelambert. au@gmail.com | Australia |
| 3 | Dr. Stefan Royaert | Cocoa breeder, MARS | stefan.royaert @effem.com | Belgium |
| 4 | Dr. Indah Anita Sari | Cocoa Breeder Indonesian Coffee and Cocoa Research Institute (ICCRI), Jl. PB Sudirman No. 90 Jember 68118 Indonesia | indah.anitasari @gmail.com | Indonesia |
| 5 | Dr. Bayu Setyawan | Cocoa Breeder, ICCRI | setyawanbayu45 @gmail.com | Indonesia |
| 6 | Dr. Haya Ramba | Director of Cocoa Upstream Technology Division Malaysian Cocoa Board (MCB), 5-7thFloor, Wisma SEDCO, Locked Bag 211, 88999 Kota Kinabalu, Sabah, Malaysia | hayaramba @koko.gov.my | Malaysia |
| 7 | Dr. Nuraziawati Mat Yazik | Cocoa Breeder, MCB | nura @koko.gov.my | Malaysia |
| 8 | Dr. Marfu Jeffrie | Cocoa Research Manager/ Director Cocoa Board of Papua New Guinea P. O. Box 532, BalivoStreet, Kokopo, ENBP. Papua New Guinea | drctrsrch.reds @cocoaboard. org.pga | Papua New Guinea |
| 9 | Dr. Romulo L. Cena | Leader of Cocoa Program University of Southern Mindanao (USM) Kabacan, Cotabato, Philippines | romulo55cena @yahoo.com | Philippines |
| 10 | Dr. Sheena B. Lucena | Cocoa breeder, USM | sblucena106 @gmail.com | Philippines |
| 11 | Dr. Pham Hong Duc Phuoc | Nong Lam University (NLU-University of Agriculture & Forestry) | phdphuoc @gmail.com | Vietnam |
| 12 | Dr. Le Thi Tuyet | NLU | tuyetlethi @gmail.com | Vietnam |
| 13 | Dr. David Mackill | Breeding Director MARS Wrigley Confectionary USA | david.mackill @effem.com | USA |

## National Delegates

| Sl. No. | Name | Designation |
|---|---|---|
| 1 | Dr. N. Kumar | Vice Chancellor, Tamil Nadu Agricultural University |
| 2 | Dr. Venkatesh N. Hubballi | Director, DCCD, Kochi |
| 3 | Dr. J. Dilip Babu | Director of Research, Dr.YSR Horticultural University |
| 4 | Mr. Sankar Narayana Bhat | Vice President, Central Arecanut & Cocoa Marketing and Processing Cooperative Ltd. |
| 5 | Dr. Thomas John | Plantation Consultant |
| 6 | Dr. D. Balasimha | Formerly Head, ICAR-CPCRI, Regional Station, Vittal |
| 7 | Dr. T.N. Raviprasad | Principal Scientist, Directorate of Cashew Research, Puttur |
| 8 | Dr. B. Suma | Professor (Hort.), KAU- CCRP, College of Horticulture, Vellanikkara, Thrissur, Kerala |
| 9 | Dr. J.S. Minimol | Assoc. Professor (Genetics & Plant Breeding), KAU- CCRP |
| 10 | Dr. K. Balakrishnan | Professor & Head, Dept. of Spices and Plantation Crops, HC & RI, TNAU, Coimbatore, Tamil Nadu |
| 11 | Dr. M. Kalpana | Scientist (Hort.), AICRP-Palms, Horticulture Research Station, Vijayarai, Andhra Pradesh |

## ICAR-CPCRI Delegates

| | | |
|---|---|---|
| **ICAR- CPCRI Kasaragod** | | |
| 1 | Dr. Anitha Karun | Acting Director, ICAR-CPCRI, Kasaragod |
| 2 | Dr. H.P. Maheswarappa | Project Cordinator, AICRP (Palms) |
| 3 | Dr. K. Muralidharan | Acting Head, Social Science |
| 4 | Dr. K.B. Hebbar | Acting Head, PB & PHT |
| 5 | Dr. Ravi Bhat | Acting Head, Crop Production |
| 6 | Dr. Vinayaka Hegde | Acting Head, Crop Protection |
| 7 | Dr. V. Niral | Principal Scientist (Genetics & Plant Breeding) |
| 8 | Dr. K. Samsudeen | Principal Scientist (Economic Botany) |
| 9 | Dr. M.K. Rajesh | Principal Scientist (Biotechnology) |
| 10 | Dr. M.R. Manikantan | Principal Scientist (Agrl. Processing) |
| 11 | Dr. R. Sudha | Scientist (Horti.-Fruit Science) |
| 12 | Dr. Neema M. | Scientist (Horti.-Spices, Plantations) |
| 13 | Dr. Krishna Prakash | Scientist (Horti.-Spices, Plantations) |
| 14 | Ms Ranjini T. N. | Scientist (Horti.-Spices, Plantations) |
| 15 | Dr. V. H. Prathibha | Scientist (Plant Pathology) |
| 16 | Dr. Pandiselvam R | Scientist (Agrl. Processing) |
| **ICAR- CPCRI RS Vittal** | | |
| 17 | Dr. C.T. Jose | Acting Head |
| 18 | Dr. S. Elain Apshara | Pricipal Scientist (Hort.) |
| 19 | Dr. M. Senthil Amudhan | Senior Scientist (Biochemistry) |
| 20 | Dr. Nagaraja, N.R. | Scientist (SS- Genetics & Plant Breeding) |
| 21 | Ms. Suchitra M. | Scientist (Horti.-Spices, Plantations) |
| 22 | Dr. Shivaji Hausrao Thube | Scientist (Agrl. Entomology) |
| 23 | Dr. Thava Prakasa Pandian | Scientist (Plant Pathology) |
| 24 | Ms. Saneera E. K. | Scientist (Agrl. Entomology) |
| 25 | Dr. Priya U. K. | Scientist (Soil Science) |
| **ICAR- CPCRI RC Kidu** | | |
| 26 | Dr. Ganesh Khadke | Scientist (Horti.-Spices, Plantations) |