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COCOINFO INTERNATIONAL

Utilization of Kopyor Coconut

(Cocos nucifera L.)
as a Potential and Opportunity
for Healthy Food Ingredients

Genomic Architecture of Coconut Tree

Drought Tolerance Increasing to
Expand Coconut Cultivation
for Food Security in West Africa

The Farmers-Participatory Approach

to Conserve and Protect Diversity
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Harnessing the Potential of Coconut Shell-based Activated Carbon as a Radar-absorbing Material

The outstanding properties and superior performance of coconut shell charcoal-based activated carbon have long been widely used in water treatment, air/gas purification, gold recovery, chemical processing, cigarette filters, automotive, nuclear, catalytic carbon, electric double-layer capacitator (EDLC) electrode material, medical, and pharmaceuticals. Having an extensive porosity and high absorption, coconut shell charcoal-based activated carbon also plays a promising radar-absorbing material (RAM), capturing the interest of researchers and creating a strong impetus to study its potential applications and development.

RAM is used to reduce or eliminate the reflection of electromagnetic waves through two main mechanisms, which include absorption and multiple reflections. In the absorption process, it reduces the intensity of waves and converts them into heat energy, while during the multiple reflections or known as destructive interference, this process helps to minimize the overall reflection of the waves. Application of RAM is not only in the military field, but also in commercial microwave communication system, and various consumer electronics such as antennas, automobile radios, mobile phones, and telecommunications base stations. It has also been used in commercial and civil settings to reduce radar scattering from large buildings near airports, potentially disrupting civil aviation radar systems. These inventions and information further confirm the coconut as the tree of life that has unique attributes deserving special support to improve its productivity, which until now is still below its potential.

The reported global annual coconut production in 2022 amounts to over 65 billion drupes producing approximately 11.8 million MT of coconut shell. In some areas, coconut shells are only considered as a product with low economic value, as waste from coconut processing industries. But, in fact coconut shells can be converted into various products such as shell-based charcoal, and this charcoal can be further processed into activated carbon and briquettes. Coconut shell charcoal can also play a critical role in mitigating the deforestation due to the extensive use of wood-based charcoal.

Collective efforts to increase global coconut production and its production efficiency are becoming increasingly imperative to meet market opportunities for activated carbon-based radar absorbent material and other economic coconut-based products. Good-quality coconut varieties continue to be identified and developed by Sri Lanka, the Philippines and other countries, and eco-friendly technologies are being developed in India to control major pests and diseases that have the potential to cause economic yield losses, as well as the polyculture farming system and coconut conservation must continue to be promoted. Given some limitations of conventional coconut propagation to better meet the high demand for improved planting materials, alternative approaches such as tissue culture technologies should be considered. Technical and financial supports for tissue culture technology optimization and commercialization are urgently needed. Greatest appreciation to coconut-producing countries in recognition of their invaluable efforts in developing the coconut sector for the benefit of farmers, industries, their respective countries, and the global community.

DR. JELFINA C. ALOUW
Executive Director
Editor-in-Chief

Sri Lanka Yellow Dwarf
A Potential Coconut Variety for Urban/Semi-urban Home Gardens

Lalith Perera[1]

The tender coconut supplies coconut water, a popular thirst quencher of health and hygienic value. Coconut water is becoming the world's number one natural beverage and hence it is gaining a wider international market, especially in USA and Europe as processed nut water and in the Gulf area as tender nuts. Sri Lanka, as one of the major coconut-producing countries, needs to capture this emerging market opportunity. Coconut production in Sri Lanka is mainly (65%) catering to the domestic market for culinary purposes and the rest for export as value-added products. King coconut and mature nut water are exported recently but their contribution to the economy is not significant compared to other coconut water exporting countries such as Brazil and Thailand. Hence the nut water industry is yet to be developed in Sri Lanka. Although it can be projected that harvesting tender nuts from existing coconut for nut water would give more return to investment and earn more foreign exchange, it will have a detrimental effect on the local coconut supply for culinary purposes and raw materials for a well-established and stable export market for kernel and coir-based products.

The evaluation of various combinations of dwarf x dwarf hybrids together with dwarf x tall hybrids and pure yellow dwarf as controls, shows yellow dwarf as a highly productive variety under optimum management conditions, especially under no moisture stress situation. The yellow dwarf under such conditions displayed an extraordinary vegetative growth and nut yield (Figure 1) and a comparable earliness in fruiting (35 months

Figure 1. Three years and 3 months old Sri Lanka yellow dwarf planted in the dwarf x dwarf evaluation trial as a control at Kobeygane site (Photo by: Lalith Perera)

is fairly resistant to *Aceria* mite (Perera et al., 2013, *CORD 29* (1), 46-51), a major microscopic pest damaging developing nuts. The above data together with its dwarf stature shows the suitability of yellow dwarf as a coconut variety for commercial planting aiming at harvesting nut water for the export market. The dwarf stature of yellow dwarf, makes this cultivar possible for planting in high density leading to high productivity. If planted for nut water production, it is advisable to plant them in the wet zone or areas with a high water table, with a reliable water source for supplementary irrigation. Brazil is the pioneering and dominating country for the coconut water industry in the world. Brazil mainly uses the Brazilian green dwarf, a cultivar characterized by its big and round shape nuts compared to the Sri Lanka Green dwarf, and its crosses planted densely and under intensive management conditions.

Table 1. Fruit Component Data at Kobeygane site

Variety/ Cultivar	Average Nut Water (ml)	Average Kernel Weight (g)
DG x SR Hybrid (dwarf x tall)	310.00	371.25
DG x SLT Hybrid (dwarf x tall)	170.50	264.25
Yellow Dwarf	374.10	298.00
DY x DG Hybrid (dwarf x dwarf)	209.70	304.50
DR x DB hybrid (dwarf x dwarf)	199.70	288.30

SR: San Ramon tall, SLT: Sri Lanka tall, DY: Sri Lanka Yellow Dwarf, DG: Sri Lanka Green Dwarf, DR: Sri Lanka Red Dwarf, DB: Sri Lanka Brown Dwarf

on average). The fruit component data (Table 1) further indicated that the volume of nut water of dwarf yellow is comparable to dwarf x tall hybrids. Previous research has indicated that yellow dwarf

The very attractive ivory-yellow color of the yellow dwarf adds aesthetic value to the precious landscape of urban and semi-urban-households. Previous research has shown that yellow dwarf is rich in unsaturated fatty acids and is better in beverage quality compared to other varieties. With all other attractive attributes, yellow dwarf additionally and more appropriately qualifies to be a superb coconut cultivar for urban and semi-urban home gardens. The fairly good amount of fresh kernel content (Table 1) of the nuts of this cultivar allows urban householders to use mature nuts for culinary purposes while it can be harvested freshly as a ready-to-drink natural beverage from their own home garden.

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Comprehensive Review of the Integrated Strategies for the Management of Major Pests and Diseases of Coconut in India

Vinayaka Hegde[1], Merin Babu[1] and A. Josephrajkumar[1]

Coconut plays a pivotal role in the agrarian economy of India. The tropical palm is susceptible to several pests and diseases. Being a perennial system interventions by chemicals are not advised and nature-protective approaches are followed to safeguard the ecosystem and environment, especially in the conservation of pollinators, defenders and scavengers. Botanicals, bioagents and need-based slow-release-semiochemical interventions are by and large very effective if adopted in community and farmer-participatory mode. Area-wide distribution of bioagents and botanical formulation in smart delivery mode targeting coconut rhinoceros beetle is found effective in reducing the pest incidence and improving the nut yield as well. Bioagent *T. harzianum* in the suppression of diseases as coir pith cake formulation is easily adopted among the farming community and strategies on improving palm health are given the greatest impetus to overcome all challenges. Digital approaches using unmanned aerial vehicle and early detectors for surveillance and diagnosis of pests are successfully commissioned. Robust diagnosis of new pathogens using molecular techniques and attempts to characterize the Guam strain of coconut rhinoceros beetle in the country is successfully targeted. Climate change cataclysm and the emergence of new pests and diseases are definite challenges for which network mission mode approach and management are crucial and need of the hour.

INTRODUCTION

Coconut palm (*Cocos nucifera* Linn.) is an integral component of the coastal agro-system in India. Although the production and productivity of coconut in India have grown up considerably in the past few decades, the prevalence of pests and diseases in the majority of the coconut areas in the country has adversely affected the coconut industry to a large extent. Challenges in pest and disease management in coconut are of several folds. Pest incursion and disease infection due to changing climate, especially in the perennial cropping system is an unavoidable threat, thus, formulation of Integrated Pest Management and effective interventions are critical in addressing the inevitable challenges to coconut cultivation in India.

PEST AND DISEASE SCENARIO IN INDIA

The coconut palm is the preferred niche host plant for a spectrum of insects, mites, rodents and pathogenic microbes. Kurian et al., (1979) enlisted 547 insects and mite species infesting coconut. Key pests of coconut in India include the coconut rhinoceros beetle (*Oryctes rhinoceros* Linn.), red palm weevil (*Rhynchophorus ferrugineus* Oliv.), black-headed caterpillar (*Opisina arenosella* Wlk.), white grub (*Leucopholis coneophora* Burm.) and the invasive pests *viz*., coconut eriophyid mite (*Aceria guerreronis* Keif.) and rugose spiraling whitefly (*Aleurodicus rugioperculatus* Martin). Rhinoceros beetle, red palm weevil (RPW) and eriophyid mite are widely distributed in all coconut-growing regions of India whereas the infestation of black-headed caterpillar and white grubs are limited to certain coconut-growing tracts. Adult rhinoceros beetles invade different parts of palms such as spear leaf, inflorescence, collar region of juvenile palms and of late even on tender nuts incurring crop loss as high as 10% (Nirula 1955, Menon and Pandalai 1960, Nair 1986, Rajan et al., 2009, Bedford 2013, Josephrajkumar et al., 2015). Feeding by coconut rhinoceros beetle on adult coconut palms is not lethal, whereas it has a significant impact on juvenile palms often affecting the initial establishment of newly planted seedlings. Juvenile and pre-bearing palms mostly below 20 years of age are more susceptible to red palm weevil infestation. Since it is a lethal pest even one percent damage is regarded as an economic threshold level (Abraham 1994, Rajan et al., 2009, Faleiro 2006). The defoliator pest *O. arenosella* attack directly affects the chlorophyll content of leaves and a crop loss of up to 45% in terms of nut yield was recorded from infested palms in the succeeding year of severe pest incidence (Chandrika et al., 2010). The black-headed caterpillar infestation is severe during summer which gets worsened in water stress conditions in coastal

Figure 1. Bud rot, killing about 3 to 5 % of coconut trees every year in endemic areas (Image source: Coconut Development Board)

Figure 2. Basal stem rot, important disease aggravated due to continuous periods, prevalent in all major coconut growing (Image source: Coconut Development Board)

Figure 3. Root (wilt) disease, debilitating disease, distributed in southern 8 districts of Kerala for last 130 years, but slowly spreading to major coconut areas in Tamil Nadu (Image source: The Hindu)

Figure 4. Stem bleeding, widely distributed, debilitating disease (Image source: Coconut Development Board)

Figure 5. Leaf blight, emerging as a major disease, Also infects nuts and causes immature nut (Image source: The Agri Guide)

regions of India. The coconut white grub species *Leucopholis coneophora* occurs mainly in sandy loam soil and attains pest status in discontinuous patches along the Western coastal tracts, especially in Kerala and Karnataka. (Abraham and Mohandas 1988, Chandrika and Vidyasagar 1993, Prathibha et al., 2018). In India, coconut eriophyid mites have spread rapidly to all major coconut-growing regions of the country within a short period after its first report from Kerala in 1998 (Sathiamma et al., 1998, Nair et al., 2000). Eco-friendly approaches to combat all these pest incursions are available and area-wide demonstrations of such strategies are validated as well.

In addition to pests, the palm is affected by many diseases from its germination to harvest, some are lethal and some cause economic loss by reducing the quality/quantity of nut yield. About 173 fungi, a few species of bacteria, viruses, viroids and phytoplasma are associated with coconut, however, only a few diseases are economically important. Among the pathogens, Phytoplasma, *Phytophthora* and *Ganoderma* are the major threat to coconut production throughout the world including India. The root (wilt) disease (RWD) caused by 'Candidatus *Phytoplasma oryzae*' related strain is one of the oldest known diseases of coconut and a major reason for low productivity in the southern states of Kerala and Tamil Nadu. The crop loss due to the disease was estimated to be about 968 million nuts (Anonymous 1985). It is a continuing threat to coconut cultivation in India. Apart from RWD, recently the association of 'Candidatus *Phytoplasma asteris*' (16Sr I) with lethal wilt disease is also noticed in certain small pockets of Tamil Nadu (Babu et al., 2021). Bud rot caused by *Phytophthora palmivora* is another lethal disease with an average incidence of less than 1%, but in certain pockets, up to 20 % of the coconut palms succumb to disease depending upon climatic conditions, soil and nutritional factors and varieties. The increase in the incidence of bud rot in India is attributed to the non-adoption of scientific cultivation practices by farmers, erratic rainfall, non-adoption of prophylactic measures, and shortage of skilled labors coupled with high wages (Sharadraj and Chandramohanan 2013). Basal stem rot caused by *Ganoderma* spp. is prevalent in the coastal and dry tracts of Tamil Nadu, Karnataka and Andhra Pradesh. The average disease incidence in general ranges from 0.6 % to 4.9 %, but in certain badly managed groves the disease incidence of up to 31.4 % was noticed (Bhaskaran et al., 1984).

Figure 6. Larva of Rhinoceros beetle, infected with Green Muscardine Fungus. Image source: Popoonsak (2020)

INTEGRATED PEST AND DISEASE MANAGEMENT STRATEGIES IN THE COCONUT-BASED FARMING SYSTEM

Crop protection strategies in coconut require a holistic approach that takes into account the integrated management of pests and diseases of coconut as well as the intercrops in a compatible way as possible. Rhinoceros beetle infestation is very common in all coconut growing areas and the wound caused by the beetle could be considered one of the major predisposing factors for the higher incidence of bud rot and leaf rot diseases (Sharadraj and Chandramohanan 2016). These diseases in turn attract the red palm weevil infestation. Hence, a customized integrated management strategy based on the pests/diseases and intercrops in a particular geographic region will yield better sustainable results. The strategy is multipronged giving equal weightage for surveillance, field sanitation, host resistance, intercropping, soil and moisture conservation, crop nutrition along with plant protection for the total enhancement of palm heath. This approach considers the coconut-based cropping system as a single unit where the intercrops and the bioresources generated in the system will be utilized effectively for pest/disease management. The evolved techniques/technologies that can form a component of integrated management strategies are given below.

Biological control

Biological control refers to the use of living organisms to manage pests/pathogens. Coconut being a perennial crop is having long-term exposure to several pests and pathogens in the field. Biological control offers cost-effective, eco-friendly and sustainable suppression of pests/diseases that suits well to a perennial cropping system. Hence, it forms one of the important components of IPM in coconut.

Most of the coconut-growing regions in India have State Government/agricultural university-supported Parasitoid Breeding Stations for the supply of parasitoids of the black-headed leaf-eating caterpillar, *O. arenosella*. This is one of the classical success stories in biological control. *O. arenosella* can be managed effectively using stage-specific parasitoids *viz*., *Goniozus nephantidis*, *Bracon brevicornis*, *Elasmus nephantidis* and *Brachymeria nosatoi* (Chandrika

Table 1. Biocontrol agents used in the management of pests and diseases of coconut

No.	Pest/disease	Biocontrol agents	Method of application
1	Rhinoceros beetle	Green Muscardine Fungus-*Metarhizium majus*	Apply *M. majus* formulation @ 5 x10^{11} spores / m^3 of pest breeding material (decaying organic matter/ manure pits)
		Oryctes rhinoceros nudivirus (OrNV)	Release 10-12 virosed beetles per ha
2	Black-headed leaf-eating caterpillar	• Larval parasitoids-*Goniozus nephantidis* & *Bracon brevicornis* • Pre-pupal parasitoid-*Elasmus nephantidis* • Pupal parasitoid-*Brachymeria nosatoi*	Release parasitoids at the following rates: *G. nephantidis* - 20 per palm *B. brevicornis* - 30 per palm *E. nephantidis* - 49% for 100 pre-pupae *B. nosatoi* - 32% for 100 pupae
3	Eriophyid mite	*Hirsutella thompsonii* Fisher	Application of talc-based preparation of *H. thompsonii* @ 20 g L^{-1} $palm^{-1}$ containing 1.6 x 10^8 cfu with a frequency of three sprayings per year to terminal five pollinated bunches along with soil-test based nutrient application with soil and water conservation measures.
4	Bud rot	*T. harzianum* CPTD 28	Place Trichoderma coir pith cake(TCPC) @2 nos. in innermost leaf axils
5	Stem bleeding	*T. harzianum* CPTD 28	Apply the paste of talc-based formulation of *T. harzianum* on bleeding patches Apply neem cake enriched with *T. harzianum* (5 kg neem cake + 100 g *T. harzianum* talc-based formulation) @ 5 kg/palm in coconut basin
6	Basal stem rot	*T. harzianum* CPTD 28	Soil application of T. harzianum (CPTD 28) enriched neem cake @ 5 kg/palm (5 kg neem cake + 100 g *T. harzianum* talc-based formulation) at quarterly intervals up to one year, followed by mulching and irrigation around the palm.
7	Leaf rot	*Pseudomonas fluorescens*, *Bacillus subtilis*	Application of 50 g talc-based formulation of *Pseudomonas fluorescens* / *Bacillus subtilis* mixed in 500 ml water to the spear leaf axil

Mohan and Sujatha 2006). The green muscardine fungus, *Metarhizium majus* (Johnst.) Bisch., Rehner & Humber and *Oryctes rhinoceros* nudivirus (OrNV) are potential candidates employed in the successful management of coconut rhinoceros beetle (Chandrika Mohan et al., 2018). OrNV was found very successful in rhinoceros beetle management in island ecosystems (Lakshadweep and Bay Islands) mainly due to the restricted movement of non-virosed adult beetles in the region. (Rajan et al., 2009). A baseline survey of coconut farmers in Kerala indicated the non-availability of biocontrol agents as the principal constraint for the adoption of IPM for rhinoceros beetles. Farmers were organized into clusters through Farmer Field Schools for imparting knowledge and skills on biological pest control. Farmer field schools enabled mutual learning as well as a better understanding of how the practices could be adopted in a larger area within a limited time. A reduction in rhinoceros beetle infestation in the FFS areas to the extent of 76-85% is an indication of the efficiency of area-wide community adoption (Josephrajkumar et al., 2019) The acaropathogenic fungus, *Hirsutella thompsonii* Fisher was found to be very effective against coconut eriophyid mite in the coconut system (Nair et al., 2005).

Figure 7. Coconut Intercrop with Turmeric. Image source: Bhalerao & Maheswarappa (2020)

The fungal bioagent *Trichoderma harzianum* (CPTD 28) is effective in the management of basal stem rot, bud rot, and stem bleeding disease. Leaf axil placement of coir pith cake formulation of Trichoderma is used as a prophylactic measure against bud rot disease. The talc-based formulations of bacterial bioagents Pseudomonas fluorescence and Bacillus subtilis are effective in managing leaf rot disease-a fungal disease complex observed in the root (wilt) disease-affected coconut palms (Srinivasan et al., 2011).

Though augmentation helps in managing many of the pests and diseases, for pests affecting the entire crown of the palm, conservation biological control is the most feasible strategy. The pesticide holiday approach aids in the conservation biological control using the aphelinid parasitoid, *E. guadeloupae* and the chrysopid predator, *Apertochrysa* sp. as well as *in situ* preservation of the sooty mould scavenger beetle, *Leiochrinus nilgirianus* Kaszab were found pivotal in the bio-suppression of the recent emergence of exotic whiteflies (Josephrajkumar et al., 2018a). Similarly, the natural suppression of coconut scale, A. destructor by the aphelinid parasitoid, Aphytis sp. is very successful and the pest is nowhere expanding in the region (Chandrika Mohan et al., 2019).

Plant-based products

Oil cakes and other plant-based formulations are a safer eco-friendly alternative in integrated management. ICAR-CPCRI has developed a botanical cake as well as a paste for the repulsion of coconut rhinoceros beetle. Soap/cake prepared from extracts of *Clerodendrum infortunatum* & *Ageratum conyzoides* admixed with neem oil is recommended for leaf axil filling against rhinoceros beetle. A paste formulation containing grease admixed with cashew nut shell liquid and neem oil was made for smearing on the pest landing zone of spear leaf also repels the beetle. This technology was area-wide evaluated in coconut growing regions of the country through AICRP on Palms and was found comparable with chlorantraniliprole sachets in terms of pest reduction (>70%) and was recommended as a technology for pan-India adoption (ICAR-CPCRI, 2016). Neem cake along with *Trichoderma harzianum* is

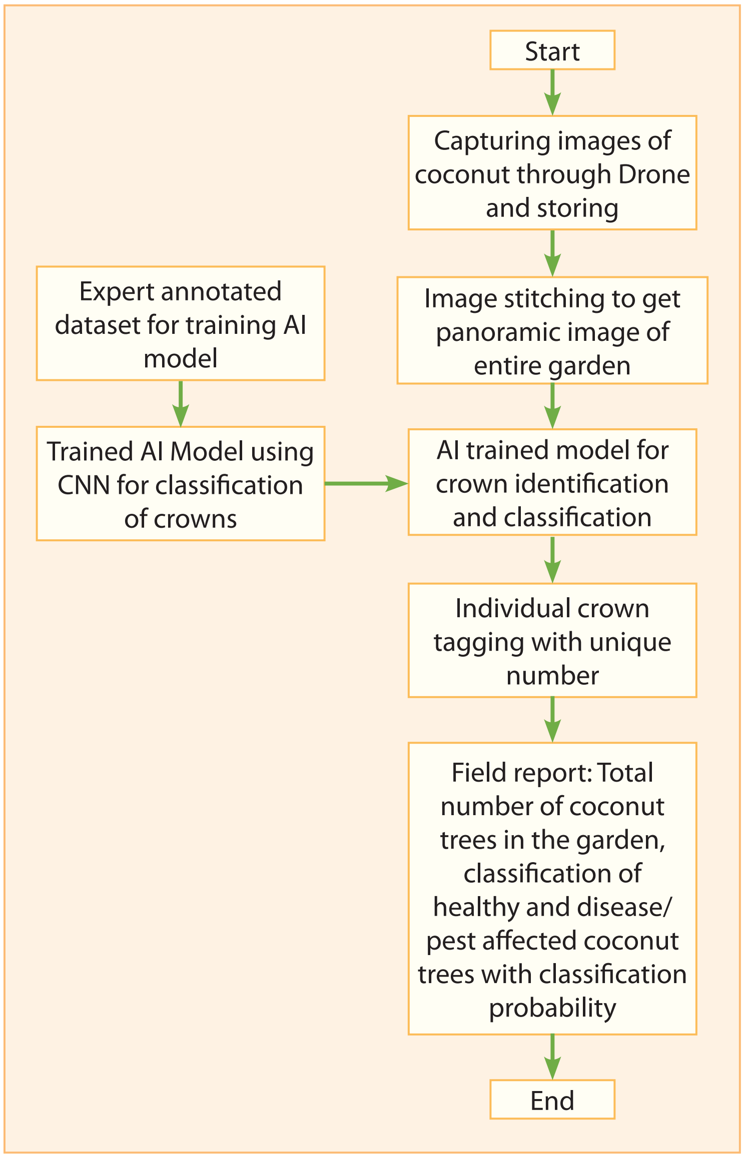

Figure 8. Pipeline developed for identification of pests/disease-affected coconut palms by UAV

effective in the management of stem bleeding and basal stem rot diseases.

Host plant resistance

Resistant varieties form the most viable and cost-effective option in managing pests/diseases, especially for perennials like palms. Coconut breeders around the world have identified some palm varieties/accessions with varying degrees of resistance/tolerance to various pests and diseases. Systematic evaluation trials at ICAR-CPCRI have led to the release of two coconut varieties [Kalpasree (Chowghat Green Dwarf), Kalparaksha (Malayan Green Dwarf)] and one hybrid [Kalpasankara (Chowghat Green Dwarf x West Coast Tall)] for cultivation in the root (wilt) disease prevalent areas (Thomas et al., 2012, Krishnakumar et al., 2015). Coconut having rounded nuts with tight tepals is found tolerant to eriophyid mite infestation. Accordingly Chowghat Orange Dwarf (COD) and Kalpa Haritha (A selection from Malayan Green Tall from Kulsekharam, Tamil Nadu) were relatively more tolerant to mite attack than other varieties (Nair et al., 2005). In general tall palms are relatively tolerant to red palm weevil infestation compared to dwarf cultivars.

Crop diversification

A cropping system with compatible intercrops attracts more pollinators and the admixture of volatile cues from various crops repels pests, reducing pest incidence and enhancing productivity. A crop habitat-based pest regression module has been developed at ICAR-CPCRI with Kalpasankara (Chowghat Green Dwarf x West Coast Tall) coconut hybrid and intercrops such as nutmeg, rambutan, banana, curry leaf, jack, marigold, custard apple, etc. for farming to fullness. Rhinoceros beetle, red palm weevil and whiteflies were significantly low in the ecological engineering plot compared to that of the mono-cropped coconut garden wherein a two to four folds increase in pest incidence could be observed (Josephrajkumar et al., 2018b). Such a system was found to be climate smart, provides habitat for pollinators and defenders, and delivers continuous income to farmers in a sustainable manner. For non-lethal phytoplasmal diseases like RWD in India, coconut farmers are advised to adopt intercropping and mixed farming along with scientific cultivation practices to ensure a satisfactory and sustainable yield even in disease prevalent areas (Sahasranaman et al., 1983, Amma et al., 1983, Bavappa et al., 1986, Muralidharan et al., 1991, Krishnakumar et al., 2015).

Diagnostic

Diagnostics plays an important role in the management of pests and diseases of the coconut palm. Early diagnosis forms the success key in the management of bud rot disease and red palm weevil. Serodiagnostic tests are being used in the production of root (wilt) disease-free seedlings (Sasikala et al., 2010). Puparium and molecular diagnostics of exotic whiteflies in the coconut system will unveil the correct identity of the pest and the natural enemy associated (Josephrajkumar et al., 2020).

Figure 8. Coir Pith based Pesticide slow release product. Image source: ICAR-CPCRI

Surveillance

To understand the pest/disease status on a wide scale, aerial surveillance using unmanned aerial vehicles can be utilized. ICAR-CPCRI has developed AI models that could detect and identify coconut crowns with 96% precision and rhinoceros beetle-damaged palms with an accuracy of 84.3%. For the detection of root (wilt) disease-affected palms, the crown classification model was used with an accuracy of 77.81%. The developed AI pipelines can be used for developing specific AI models for the detection of all other major pests and diseases of coconut (Kadethankar et al., 2021 a & b).

TECHNOLOGY REFINEMENT

Refinement in management techniques

The IPM/IDM strategies evolved/developed are subject to refinement and modifications based on feedback from farmers. Newly available pesticide formulations are evaluated in search of better alternatives for the existing recommendations. The method of delivery of plant protection inputs and mode of adoption of technologies are also being refined and validated. Preparation of botanical cake from the weed *Clerodendrum infortunatum* is a technology refinement made for the prophylactic management of coconut rhinoceros beetle. Conditioning the parasitoids of black-headed caterpillars to insect frass will lead to effective host-seeking ability and enhance parasitism. The placement of beehives for enhanced nut yield is also a refinement to improve the productivity of palms. About 5% to 7% nut yield enhancement was realized by placing five beehives per hectare. The technologies are evaluated in a farmer-participatory mode (Josephrajkumar et al., 2019). Most of the palm protection technologies were found to be more effective and economic in area-wide/community-based adoption. Aggregation pheromone lures are available for easy trapping of coconut rhinoceros beetles and red palm weevils. Embedding the pheromone molecules in a nanoporous matrix would make a controlled and slow release of the pheromone molecule resulting in a long-term pest catch into the trap. Correct placement of traps in a garden and the right time of placement with community-level adoption of this technology are key factors for realizing success in this eco-friendly novel technology (Josephrajkumar et al., 2016).

Most of the commercially available talc-based formulations of Trichoderma have a shelf life of 120-150 days and the formulation has to be mixed with water before applying to the coconut crown. Chandramohanan et al., (2013) developed a Trichoderma coir pith cake (TCPC) formulation of Trichoderma having a long shelf life of 10 months. The cake formulation can be placed directly on the leaf axils without mixing with water ensuring ease of application. Field trials showed that TCPC formulation is effective in the management of stem bleeding and bud rot diseases of coconut.

Refinement in diagnostics

The constantly evolving pests and pathogens demand refinement in diagnostic techniques for

*Figure 9. Whiteflies (*Aleurodicus dispersus *Russell) infesting coconut leaf. Image source: (goodhands.lk)*

accurate and early detection of new variants. The nested PCR (Manimekalai et al., 2010), real-time PCR (Manimekalai et al., 2011) and LAMP (Nair et al., 2016) developed for coconut RWD diagnosis, lack consistency in the detection when a large number of root (wilt) affected coconut samples were tested and further refinement of these techniques are necessary for reliable and rapid detection of RWD in the early stage of infection (Hegde et al., 2016).

ICAR-CPCRI initiated a public-private partnership program and evolved a digital device for the timely detection of pest infestation so that curative measures could be undertaken at the appropriate time. Timely detection of red palm weevil (*Rhynchophorus ferrugineus*) infestation is the key to curative management and an acoustic-based sensor detector embedded with artificial intelligence could diagnose the presence of the weevil grubs (Josephrajkumar et al., 2021).

CHALLENGES IN MANAGING PESTS AND DISEASES IN A TROPICAL PERENNIAL SYSTEM

Being perennial and cultivated mainly in humid tropics, coconut palms are vulnerable to pests and diseases throughout their life span. Unlike annual crops, the microclimate in the plantation favors the buildup of inoculum and it is difficult to eradicate the inoculum completely from the infected garden.

New strains of pests/pathogens

A new biotype of rhinoceros beetle known as coconut rhinoceros beetle-Guam biotype (CRB-G) which could not be controlled by the entomopathogenic virus, *Oryctes rhinoceros* nudivirus (OrNV) first reported from Guam in 2007, is expanding to several Pacific Island countries including Papua New Guinea (2009), Hawaii (2013) and Solomon Islands (2015) and forms a threat to the culturally iconic and economically vital palms. Surveillance in India, however, indicated more than 0.7% natural infection of rhinoceros beetle by nudivirus highlighting the absence of the Guam strain. Constant surveillance is required for the identification of pesticide/fungicide-resistant strains also.

Invasive pests/diseases

The country has already witnessed the infestation by several invasive pests on coconut *viz*., coconut eriophyid mite (*Aceria guerreronis* Keifer Acarina: Eriophyidae), Asian grey weevil (*Myllocerus undatus* Marshall Coleoptera: Curculionidae), whiteflies and nesting whiteflies (*Aleurodicus dispersus* Russell,

Figure 8. Coir Pith based Pesticide slow release product. Image source: Babu et al. (2021)

Aleurodicus rugioperculatus Martin, *Paraleyrodes bondari* Peracchi, *Paraleyrodes minei* Iaccarino and *Aleurotrachelus atratus* Hempel Hemiptera: Aleyrodidae) (Josephrajkumar et al., 2020). The quarantine and research systems of the country are working hand in hand to prevent the entry of invasive pests and diseases of coconut.

Host range expansion

Host range expansion of the existing pests and pathogens pause severe threat. The lethal wilt disease of coconut is due to the expansion of the host range of '*Ca. P. asteris*'. Host range expansion enhances the survival rate of pest/pathogen. It is influenced by the physiology of the host/pest/ pathogen, population dynamics and environment. In-depth, studies are required to elucidate the factors leading to the expansion of the host range as this is a complex system where many biotic and abiotic factors interact at various levels.

Localized outbreaks of minor pests/ diseases

Localized outbreaks of slug caterpillar, hispine beetle, coreid bug, leaf blight and leaf spots have also been observed in isolated pockets in various tracts. Of late, the minor pathogen *Lasiodiplodia* spp. is also being emerged as a major pathogen causing various types of disease symptoms in coconut. Factors such as host genotype, microclimate, crop protection measures & cultural practices undertaken play a role in the transition of minor pests to major status.

FUTURE THRUST

The development of robust diagnostics for major diseases is essential. Evolving biocontrol agents to cope with the changing climate is very crucial. Development of pest and disease surveillance system by unmanned aerial vehicle (IoT and AI-based) aid in the area-wide and periodic surveillance of pests/diseases. Identification of molecular markers for the selection of resistant genotypes will give a new impetus to resistance breeding programs. The formation of an International Network on Coconut Pest Management (INCPM) to share the research developments and resources in diagnostics & management will strengthen the pest management system of resource-poor countries especially for tackling invasive pests & diseases.

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Expanding Coconut *In-Situ* Conservation: The Farmers-Participatory Approach to Conserve and Protect Diversity for Use of Genetic Resources

Erlene C. Manohar[1]

The vast diversity of coconut and its global economic importance necessitate its preservation and utilization. It is undeniable that conservation is the key to protect crop diversity and is the basic component of the breeding program in agriculture. Hence, conservation, varietal crop improvement and selection of genetic resources to improve coconut productivity and production of quality products are the core functions of the International Coconut Genetic Network (COGENT). Formerly, COGENT was under the aegis of Bioversity as the International Coconut Genetic Resources network. Recently, it was transferred as a program of the International Coconut Community (ICC) and plays a pivotal role in ensuring effective conservation and use of coconut genetic resources. Its primary task is to build coconut stakeholders' capacity and resilience across the value-chain for conservation, exchange and use of genetic resources. Moreover, it offers a golden opportunity to link coconut genetic resources conservation more effectively with their use. Given these key functions, COGENT's initiatives are geared towards improving industry productivity and livelihoods of coconut farming households/communities through the judicious utilization of valuable genetic resources.

Coconuts can be preserved either through *ex-situ* or *in-situ* conservation. *Ex-situ* conservation as defined, comprises all coconut germplasm currently maintained as living trees in the field genebanks, screen houses, and elsewhere beyond their host agroecosystems. It includes *in vitro* conservation, as well as cryopreservation of pollen, embryos,

Figure 1. Appraisals of the International Coconut Genebanks (ICG). From left to right: I

and embryogenic callus. Whereas, in situ refers to the on-site conservation of coconut species in their natural habitats and environment in which genetic diversity is maintained in the agroecosystems where it has evolved.

In per COGENT records, there are more than 1,000 Accessions and 450 identified populations which are collected in the *ex-situ* genebanks. COGENT was able to facilitate the establishment of 5 International Coconut Genebanks (ICGs) and 19 National Coconut Genebanks (NCGs) hosted by the government of their respective host countries. These ICGs were assigned in five coconut growing regions, the ICG of Southeast Asia (ICG-SEA) is in Manado, Indonesia, for the Latin America and the Caribbean countries (ICG-LAC) is in Aracaju, Brazil, while India is the host country of the ICG in South Asia and the Middle East (ICG-SAME), for the ICG of the South Pacific (ICG-SP) it is in Papua New Guinea, and the ICG of Africa and Indian Ocean (ICG-AIO) region is located in Ivory Coast. Whereas, the National Coconut Genebanks (NCGs) of Philippines, Malaysia and Sri Lanka are recently reported to have vast collections with well-maintained genebanks. Survey of the National Coconut Genebanks NCGs) is a priority to generate a comprehensive review of the coconut diversity globally. Moreover, re-visits of the agreements and commitments through consultative meeting with policy makers of the of the genebanks host countries is proposed by COGENT to ICC to discuss renewal of commitment and declaration of intent to host *ex-situ* coconut genebanks. The aim is to reactivate activities of the genebanks for better management, to gain strong support system and access local and international fund sources.

In the recently conducted appraisal of ICGs from 2020-2022, challenges and status of the genebanks were reported and immediate attention is needed to address issues and concerns of the host institutions of the ICGs. As reported, these are concerns on inevitable risk factors such as climate change impacts like calamities, pests and diseases and sustainability of resources to support maintenance and regeneration activities common in the five international genebanks. Likewise, biosecurity restrictions for safe movement of germplasm which deter the germplasm exchange and data management system are the top problems. These were due to the inadequate commitment and compliance to the agreements of policy makers despite the explicit provisions in Article 15 of the FAO-ITGRFA. Further, it was also pointed out that lack of farmers' participation and awareness of the value of genetic diversity conservation and its use are the compelling key areas to be addressed in the Global Strategy Plan of COGENT as specifics of the crafted COGENT's Road Map in 2022.

REVIEW OF LITERATURE

As per COGENT report, 24 countries have collected and conserved coconut germplasms in 19 national field genebanks and in five multi-site International Coconut Genebanks (ICGs) established in the 1990s. COGENT recognizes the limitations of the *ex-situ* field genebanks due to the nature of coconut as

CG South-East Asia, ICG South Asia & Middle East and ICG Latin America & Caribbean.*

a perennial crop and the restrictive biosecurity policies in the germplasm exchange. By using on-farm conservation or *in-situ* conservation, it is possible to conserve more diversity, especially diversity that is directly useful to farmers. To date, limited observations have shown that very few farmers seem to pay any special attention to phenotypic and other differences in coconut types that they grow. Hence, the so-called indigenous knowledge on coconuts seems to be limited (Duloo, 2005). Nevertheless, there are some who recognize this well, and should be the targets for on-farm or *in-situ* conservation efforts.

As reported by Bioversity Alliance and CIAT, 2020, among the 24 registered coconut genebanks, at least 16, including 3 out of the 5 international genebanks, do not have enough capability, laboratory space, equipment, staff, and/or a budget needed to make reliable controlled pollinations for the rejuvenation and/or maintenance of the germplasm Similarly, with the recent appraisal of the five *ex-situ* International Coconut Genebanks (ICGs), challenges and gaps were identified and currently, conservation is facing a crisis. It was recommended that the most efficient way to conserve coconut diversity should include a multifunctional approach, involving the conservation of additional appropriate crops or species by the same team, at the same site or in the same laboratory. It was emphasized that multifunctional approaches integrate functional genebanks and harness the latest developments in tissue culture and cryopreservation that will help address the unique constraints facing coconut conservation and ould help strengthen the networks and communications needed to ensure effective conservation (Bourdeix et al., 2020).

Collection of coconut germplasms

Further, it was stressed to have effective on-farm conservation, knowledge on the effects of farmers' practices on the extent and distribution of genetic diversity information on history of coconut cultivation and indigenous knowledge and actual genetic diversity measurements may be required. It is now possible to monitor and estimate genetic diversity using molecular markers for coconuts (Foale, 1992; Ashburner and Rhode, 1994; Lebrun et al., 1998; Mpunami et al., 1998; Perera et al., 1999). Participation and cooperation of local people, researchers, conservationists and non-governmental organizations (NGOs), are essential ingredients of success for the sustainability of on-farm conservation efforts. Furthermore, any in situ conservation program must benefit the local communities. Establishment of areas of intensive

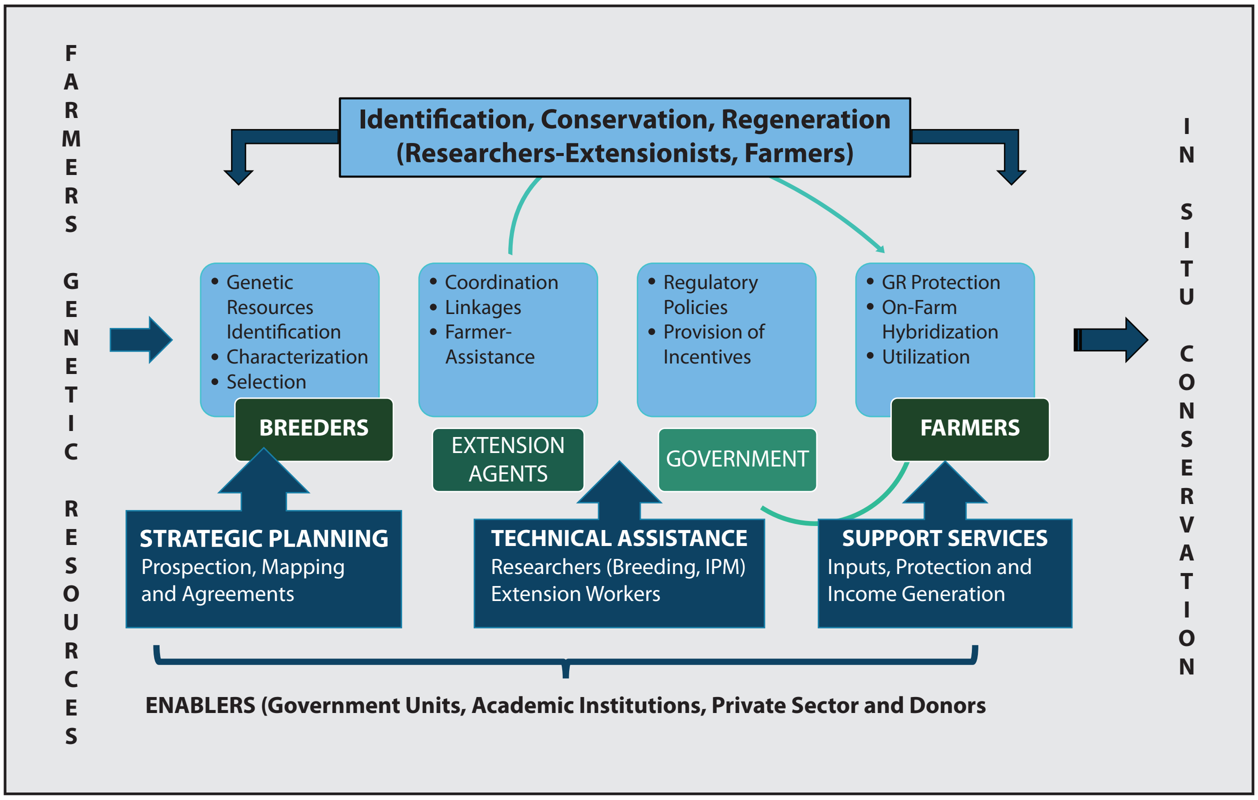

Figure 2. Pipeline developed for identification of pests/disease-affected coconut palms by UAV

management or high yielding plantations would assist long-term sustainability of in situ conservation program (Dulloo et al., 2005).

There are two complementary genetic conservation measures that are available for coconut - the field gene bank and *in-situ* conservation systems. *In-situ* conservation system has a greater potential to secure our existing coconut genetic resources in view of the nature of coconut, its cultivation system, and the preference of the farmers. Data shows that there is a great diversity of coconut kept by farmers on-farm, and that coconut farmers still prefer to plant their traditional tall varieties instead of the recommended new ones (Sangalang, 2004). As further explained, in coconut growing areas, evidences show that the level of conservation of existing stands is highly and significantly associated with the extent of gainful coconut-based farming systems/enterprises on farm. In situ conservation of coconut genetic resources through Coconut-Based Farming Systems (CBFS) strongly suggests that profitable coconut-based enterprises are the keys to the successful on-farm or *in-situ* conservation of coconut genetic resources. This involves the massive coconut genetic resources assessment to identify *in-situ* conservation sites especially in countries with vast diversity. Secondly, the promotion of gainful coconut-based farming systems/enterprises in the identified sites of the respective identified countries to provide livelihood to the farmers (Sangalang, 2004).

OBJECTIVES

To expand the coconut *in-situ* conservation through the active participation of farmers in partnership with researchers and extension workers guided by science-based tools to complement the *ex-situ* conservation in the ICGs/NCGs established by COGENT.

WAYS TO HARNESS THE COCONUT DIVERSITY *IN-SITU* CONSERVATION

The aim of COGENT is to adopt practical strategies to address the *ex-situ* conservation challenges and ensure the preservation of the coconut genetic resources and use of the industry now and beyond. With the resilience and adaptive nature of coconut in its ecological evolution, maintenance of coconut genetic diversity in the agroecosystems where it has evolved is highly feasible. Hence, *in-situ* conservation specifically in major coconut growing countries is the strategic and sustainable approach for the perpetuity of the indigenous genetic resources.

Figure 3. Coconut plantation with canal, one of example plantation with good practice management

However, there are key elements to connect in the execution of the in situ conservation. The support of the policy makers of the government is a major consideration to be able to institutionalize this strategy of conservation. These should be in full considerations to implement effectively the farmers' participatory *in-situ* conservation approach.

1. The need for the **support of the government** to incentivize the farmer-based *in-situ* conservation as a long-term national program with set of policies for sustainability.
2. **Partnership of breeder and farmers** in the implementation of science-based protocols to ensure authenticity of the genetic resources to be conserved and guided on-farm hybridization activities.
3. Provision of **research support** related to *in-situ* conservation to accelerate proof of concepts at the farmers' field such as genetic and phenotypic characterization of the genetic resources at farmers' field.
4. **Extension services** for diversity mapping, prospection and knowledge transfer to coconut farmers of the *in-situ* conservation protocols.
5. Regular **appraisal of the farm management** and performance of the *in-situ* conserved genetic resources is mandatory to be conducted by the breeders, extension workers and the farmers to ensure proper maintenance and compliance to the set of protocols.
6. Maintaining a user-friendly **database management system** and breeders guided standards data collection with government institution as the administrator of the system and shared by key players of the ***in-situ*** conservation.

As presented in Figure 2, the key activities, players and support system are interconnected to execute the proposed scheme to expand the participatory *in-situ* conservation. Major activities such as identification, conservation, selection and regeneration should be jointly to be undertaken by researchers, breeders and the farmers. Strategic planning has to be under the guidance of the breeders from prospection, mapping of target sites and crafting of technical agreements with the farmers. Extension workers shall facilitate the delivery of knowledge from the researchers (breeders) such as assisted hybridization, Integrated Pest Management and Good Agricultural Practices through the use of extension tools for technology delivery and transfer. Whereas, the government through the national programs and sustainability plans has to ensure sustainability of fund support to ensure continuity of the long-term activities. With the convergence of the various key players in the loop of the *in-situ* conservation, the farmers crucial role and awareness has to be congruent to the ultimate goal of conservation indigenous genetic resources and its importance. Additionally, engagement of government on policy implications, R & D program of academic institutions, logistical support of donor agencies are vital elements on how to strategically execute sustainable and harmonized efforts of the industry stakeholders in expanding coconut conservation initiatives of COGENT.

Based on the conceptual framework, there are six components to ponder to create a workable participatory approach involving farmers, researchers, extension workers, policy makers and the private sector. For each of the component connectivity and complementarity should be the guiding principle to effectively execute this concept. The major components are the following:

Figure 4. Regenerating the collections is imperative and has to be undertaken guided with a set of scientific protocols

A. **Conservation**. This will entail the accountability of the breeders to provide the technical knowledge and the skills in preparing the farmers to understand the scientific basis of preserving genetic resources and its use. The existence and evolution of coconut diversity has to be the core idea on how the farmers will be able to appreciate their participation in conserving their own genetic resources. The theory of crop improvement through breeding is the essence of how genetic resources are of significant value to the farmers. Hence, the *in-situ* conservation is the pathway to engage farmers as the ultimate conservationists especially in the case of coconut as a perennial crop.

B. **Regeneration**. In any conservation, regenerating the collections is imperative and has to be undertaken guided with a set of scientific protocols. The breeders have to capacitate the farmers in maintaining their indigenous genetic resources that were identified in their community.

C. **Expansion**. Increasing the number of accessions has to be done in the area where the identified variety was prospected. Establishing the mass source for *in-situ* conservation has to be provided with incentive as a program of the government. Farmers' interest will heightened with the monetary value of preserving and propagating the genetic resources for the on-farm conservation.

D. **Appraisal**. Regular monitoring of the operational farm management activities and performance assessment has to be part of the planning and appraisal system must be participatory. Field visit and strong coordination with farm-owners, extension workers and breeders should be established.

E. **Technologies**. Science-based tools to support *in-situ* conservation is a must. The morphological descriptors are not sufficient to fully characterize the identity of the germplasm. The use of molecular characterization of the identified farmers' varieties is vital to ensure authenticity and relatedness of the varieties at farmers' field. In same manner that in using *in-situ* conserved germplasm for on-farm hybridization using the Assisted Pollination Technique genetic traits has to be determined. These conserved varieties can be used as mother trees or source of pollen depending on the superior quality traits that can be of use for selection of high yielding varieties or for disease resistance breeding. High quality varieties can be mass propagated using the coconut tissue culture for distribution or germplasm exchange. As such, generated technologies will ascertain the cogency of adopting the incentivized farmers' *in-situ* conservation.

F. **Empowerment**. In all of these components, building the skills and interest of the farmers are of the essence of this approach. Providing the basic knowledge of conservation, varietal selection and practical breeding techniques need to be simplified through levelling of expectations and identifying the knowledge gaps between researchers, extension workers and farmers. Participatory approaches of technology development can be utilized in investing to a sustainable *in-situ* or on-farm conservation scheme. It has to be contemplated that one of the expected outputs from this scheme is enhancing the indigenous knowledge and farmers' skills in participatory technology, development, validation and emulation.

Figure 5. Providing the basic knowledge need to be simplified through levelling of expectations and identifying the knowledge gaps between researchers, extension workers and farmers

METHODOLOGY

In initiating the incentivized farmer-participatory *in-situ* conservation, several activities have to be planned and to be undertaken efficiently. This scheme is practical, farmer-friendly and logical approach of conservation with scientific back-up as a form of technology transfer and utilization. Linking each activity is the key for sustainability of the participatory *in-situ* conservation. Maintaining and improving the genetic resources that evolved in its original habitat has to be linked to the farmers as the ultimate conservationists. However, this needs to be supported with science-based generated tools to ensure true identity and traits of the conserved germplasm. Also, the government support is vital to draw the interest of farmers to participate in the coconut diversity conservation. Professionalizing farmers through capacity building through and on-farm learning process of conservation is proposed for a long term support of the government to an incentive-based program. Hence, listed activities need to be stringently followed for effective farm management of the *in-situ* germplasm conservation.

1. Identification of active farmers and extension agents in the conduct of prospection of coconut population and gathering of baseline information.
2. Selection of indigenous parentals with special traits through farmer-participatory performance appraisal in its ecological origin.
3. Promotion of the varietal field performance for use in breeding using the extension tools.
4. Conduct of the coconut Farmers' Diversity Fair for *in-situ* conservation and selection of indigenous genetic resources.
5. Mass propagation of the indigenous genotypes with superior quality traits at farm level.
6. On-farm hybridization via adoption of the assisted-pollination protocol through extension and farmers training.
7. Provision of the molecular testing to warrant authenticity and genetic relatedness of the populations and hybridity testing of farmer-produced hybrids/OPVs supported by breeders.
8. Strategic planting of hybrids and OPVs through science-based site suitability assessment.

Figure 6. Implementing comprehensive planning, protocols, promotion, integration, capacity building, extension, institutionalization, incentivized schemes will enhance the productivity, economic viability, and conservation of coconut genetic diversity

9. Adoption of farmer-to-farmer extension modalities in mass propagation of selected genotypes.
10. Massive planting of OPVs with quality traits and hybrids to increase coconut productivity.

RECOMMENDATIONS FOR ADOPTION OF THE FARMER-PARTICIPATORY AND INCENTIVIZED *IN-SITU* CONSERVATION

1. Comprehensive planning of the strategic appraisal of the proposed *in-situ* conservation farms with the experts including farmers and extension workers.
2. Develop a user-friendly prospection protocol with levelling of knowledge and skills of the appraisal team using the GIS tools for accuracy of real time data.
3. Promotion of the On-Farm Hybridization to gain the support of the policy makers and to boost the interest of farmers to engage in this activity.
4. Integrate science-based tools in the conduct of participatory validation, verification and selection of genetic resources at farmers' field.
5. On-farm capacity building and skills development of farmers with the technical support of breeders and extension workers.
6. Develop Integrated Pest and Disease Management, Good Agricultural Practices to ensure climate-resilient *in-situ* established farms.
7. Expand the establishment of the farmer-based *in-situ* conservation through direct farmer-to-farmer extension for conservation of the indigenous genetic resources at farmers' field.
8. Link diversity protection to income-generating activities such as planting of high-value crops, on-farm processing and seedling production to increase economic viability of the *in-situ* conservation farming.
9. Institutionalize developed policies on incentive-based on farm conservation to boost farmers interest considering that farmers are the ultimate conservationists.
10. Inclusion of incentivized scheme in the national program of the government to improve productivity and protect coconut genetic diversity.

In conclusion, harnessing the participatory *in-situ* conservation protocol is a cogent and doable solution to ensure stability of diversity protection. The farmers participation in conservation of genetic resources is the pathway in improving the coconut landscape of most coconut growing countries. This will complement the existing collections in the ICGs and NCGs. However, there a need for an incentivized scheme and coconut-based farming system as positive indicators of *in-situ* conservation. This will create a strong commitment of farmers to the participatory *in-situ* conservation integrated with economically-viable coconut-based farming systems/enterprises in the identified sites to augment income for the farmers.

It was emphasized in the conceptual framework (Figure 2), to pursue and achieve the desired goal of conserving high-valued genetic resources, concerted efforts of the key players shall serve as the strong foundation of a sustainable incentive-based *in-situ* conservation. Policies has to be a subset of a well-structured conceptual framework of the *in-situ* conservation reflecting incentives for coconut farmers active participation. With Participatory *In-situ* conservation Scheme (PICS), the farmers must be equipped with science-based tools with the provision of experts' guidance. It can be proven through the theory of change that farmers can be breeders and breeders need farm immersion as farmers to identify indigenous genetic resources and expand scope of coconut conservation, breeding and selection process for varietal improvement program. Equitable participation and gains are expected from this conservation approach for coconut that will lead to sustainable coconut diversity protection, better conservation management, use of genetic resources and with impact to livelihood of farmers.

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Utilization of Kopyor Coconut (Cocos nucifera L.) as a Potential and Opportunity for Healthy Food Ingredients

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Indonesia has a variety of potential plantation commodities. As reported by the Ministry of Agriculture of the Republic of Indonesia, Indonesia has several superior plantation commodities, including oil palm, rubber, coffee, cocoa, and tea. These leading commodities continue to be directed by the Indonesian government to achieve a target export value of up to 1,400 trillion in 2024. One of the plantation commodities above that is strategic enough to boost the economies of farmers in Indonesia is kopyor coconut. Kopyor coconut is a coconut that has a genetic disorder. The characteristics of the disorder are found in the fruit flesh that is soft or detached from the shell, the relatively small amount of coconut water, and the distinctive aroma that is different from ordinary coconut meat. This trait is the result of spontaneous mutations in the local part of the mayang. The distinctive and unique taste of kopyor coconut meat is what attracts consumers to buy it. The kopyor type of coconut is also similar to soft coconut flesh in the Philippines, namely the Makapuno coconut, whose flesh has a 'sponge' texture that thickens as the fruit ripens. (Maskromo et al., 2016).

Kopyor coconut economic opportunities are very promising, with prices at the farm level that vary quite a bit, starting from Rp. 15,000 to Rp. 35,000; even at the consumer level, they reach Rp. 30,000 to 60,000 per item. The high price of kopyor coconuts is due to the large amount of public consumption but has not been supported by the limited availability of seeds and coconuts (Nurjayanti and Awami, 2017). In addition to taste, aroma, and texture, coconut

kopyor also has a higher nutritional content than regular coconut. According to research by Santoso et al. (1996), kopyor coconut has a higher nutritional content, such as minerals and vitamins, and also contains low fat and fatty acids equivalent to ordinary coconut oil. Kopyor coconut flesh contains short-chain saturated fatty acids, namely lauric acid, at 37.93%–43.39% (Tenda & Karmawati, 2014), 46.11% (Gunathilake et al., 2009), and 48–51% (Srivastava et al., 2016). Lauric acid is a component that is easily digested and absorbed by the body, functions as an anti-microbial (Parfene et al., 2013; Widianingrum et al., 2019), is an anti-cancer, is equivalent to breast milk, and increases energy (Novarianto & Tulalo, 2007). The content of short chain fatty acids is easily absorbed by the human body because the size of the molecule is relatively small, so it is easily metabolized into energy and not excreted into fat or cholesterol tissues (Hasan et al., 2013).

However, the utilization of kopyor coconut meat to be used as healthy food is not yet popular in the community because, currently, people only know kopyor coconut as a drink, namely kopyor ice. This should specifically disseminate its benefits for health, so that the public, both consumers and farmers, will know more about the benefits and farmers will be more active in producing kopyor coconuts as a whole in Indonesia. The development of production and utilization of fresh kopyor coconuts is quite prospective because it is in line with food diversification, increasing public awareness of healthy food, and the development of agricultural industries. For this reason, the author intends to examine the use of kopyor coconut as a potential and opportunity as a functional food that is nutritious and useful for the health of the human body.

KOPYOR COCONUT MEAT'S NUTRITIONAL VALUE

Table 1. Fatty acid content of Kopyor Kalianda Coconut and Dwarf Kopyor Coconut from Pati

Types of Fatty Acids	Composition (%)			
	Kopyor Kalian-da	Genjah Kuning Kopyor Pati	Genjah Brown Kopyor Pati	Genjah Green Kopyor Pati
Kaprat (C10:0)	4.877	6.386	7.342	7.825
Laurat (C12:0)	37.939	43.392	42.864	43.269
Miristat (C14:0)	14.085	19.274	20.051	19.548
Palmitat (C16:0)	7.616	12.481	12.335	13.674
Stearat (C18:0)	1.21	2.576	2.852	3.855
Oleat (C18:1)	7.341	7.678	7.335	6.942
Linoleat (C18:2)	1.655	4.240	3.719	4.317
Linolenat (C18:3)	0.211	-	-	-

Source: Tenda & Karmawati, 2014

Kopyor coconut does have its own uniqueness when compared to ordinary coconut, where the kopyor coconut meat is not attached to the coconut shell itself. According to (Maskromo et al., 2016) the nature of kopyor, which is thought to be the result of this natural mutation, is expressed in the form of endosperm abnormalities with a crumbly texture, and apart from the shell of the coconut fruit, which has very diverse uses. The flesh of an eight-month-old young coconut is generally only limited as a raw material for coconut ice drinks. Meanwhile, young coconut water is consumed directly as a fresh drink along with the fruit flesh or mixed with other fresh fruits. Just like Indian society, consuming fresh coconut is a routine part of the diet for many people in this tropical country, so the need for coconut is increasing along with understanding the effects of fresh coconut on various aspects of health (Vijayakumar et al., 2018). The components of fruit flesh and coconut water contain quite good nutritional potential. Table 1 presents the nutritional composition, especially the fatty acid content of the Dwarf kopyor coconut varieties from Central Java Pati and Kopyor Kalianda Coconut, South Lampung.

In Tables 1 and 2, the fatty acids in kopyor coconut meat are dominated by lauric acid. According to Leorna & Israel (2017), most of the components of saturated fat are MCFA, which make up more than 50% of total fat, especially lauric acid, the dominant fatty acid, which accounts for more than 40% of total fat. In addition to the fat composition of fresh coconut, which is extracted into pure coconut oil with a high content of biologically active components, it can provide an antioxidant effect (Nevin & Rajamohan, 2006). Especially for kopyor coconut, the meat composition contains quite high levels of proteins such as aspartate, arginine, and glutamate (Santoso et al., 1996; Tenda & Karmawati, 2014).

Table 2. Fatty acid content of Kopyor Kalianda Coconut and Dwarf Kopyor Coconut from Pati

Types of Fatty Acids	Composition (%)		
	8 Month	9 Month	10 Month
Caproic	0.20	0.32	0.28
Caprrylic	4.46	5.65	5.66
Capric	4.31	5.21	5.13
Lauric	43.41	46.91	45.85
MCFA	52.38	58.97	56.92
Myristic	17.29	16.37	17.38
Palmitic	8.49	6.40	6.99
Stearic	2.33	3.04	3.3
Saturated Fat	80.59	83.97	84.66
Oleic	7.14	3.26	3.19
Linolenic	1.13	0.28	0.47
Arachidonic	ND	ND	ND
Behenic	0.07	0.06	0.06
Lignoceric	ND	ND	ND
Unsaturated Fat	0.02	ND	ND
Lipid	8.27	3.55	3.66
Peroxidation	-	-	-

ND = Not Detected, Source: Leorna & Israel, 2017

BENEFITS OF KOPYOR COCONUT MEAT

Coconut meat is indeed able to meet basic human needs, both in terms of food, drink, and medicine. Therefore, kopyor coconut is called a functional food because it is able to provide benefits for human health apart from its nutritional content (Patil & Benjakul, 2018). Most of the nutritional content of saturated fat in coconut is easily digested quickly into energy and is not stored in the body (Zentek et al., 2011), the MCFA content in kopyor coconut is more effectively absorbed and metabolized in the body. MCFA can also overcome obesity by reducing adiposity (Zicker et al., 2019). In particular, MCFA in virgin coconut oil can function as antioxidants, anti-inflammatories, lipid-lowering agents, and cytoprotectives, which can be attributed to its higher polyphenols (Narayanankutty et al., 2018). Phenolic compounds contained in virgin coconut oil include protocatechuic, vanillic, caffeic, syringic, ferulic, and pcoumaric acids and catechins (Marina et al., 2009). Phenolic compounds can reduce signs of aging and improve physical fitness (Everitt et al., 2006), have anti-inflammatory, antinociceptive, antimicrobial, and antiviral effects, prevent kidney inflammation, and are antidiabetic, so they are considered functional food supplements (Famurewa et al., 2017).

Coconut is a natural source of several phenolic acids and flavonoids with strong antioxidant capacity and can be used as a natural source of antioxidants (Arivalagan et al., 2018). Kopyor coconut is a type of coconut, so it can function as an antioxidant. The results of the study of Tenda & Karmawati, (2014) stated that kopyor coconut has derivatives of phenolic compounds, namely 0.12% tyrosine and 0.073% phenylalanine, each of which is found in yellow early maturing kopyor coconut from Pati Regency, Central Java. In addition, other phenolics are lignin at 3.98% in dikiry or kopyor coconut (Gunathilake et al., 2009).

Consuming polyphenolic compounds can provide health benefits. Antioxidants function to overcome

Table 3. Composition of Antioxidant Compounds in Fresh Coconut Meat

Parameter	Fresh Coconut Meat	Fresh Coconut Meat Without Testa	Testa/Skin of Fresh Coconut Meat
Total phytosterols (mg/100 g)	50.27 ± 1.5	30.66 ± 0.2	50.97 ± 0.1
TPC (mg/100 g)	0.7 ± 0.02	0.2 ± 0.04	0.5 ± 0.02
Phenolic acids (µg/100 g)			
Gallic acid	103.9 ± 2.2	15.9 ± 0.7	12.6 ± 2.8
Hydroxybenzoic acid	127.4 ± 1.7	34.7 ± 1.1	55.1 ± 1.1
Vanillic acid	ND	ND	ND
Syringic acid	ND	37.3 ± 1.1	26.6 ± 0.9
Coumaric acid	48.9 ± 0.0	ND	230.6 ± 3.5
Caffeic acid	ND	ND	27.4 ± 2.0
Ferulic acid	5.4 ± 0.4	ND	5.0 ±1.0
Cinnamic acid	9.8 ± 0.3	6.9 ± 0.9	31.7 ± 0.2
Total	291.4	94.8	389.0
Tocopherols (mg/100 g)			
αT	3.6 ± 0.0	2.5 ± 0.0	0.04 ± 0.0
β + γT	ND	ND	4.0 ± 0.1
αT	ND	ND	2.9 ± 0.4
αT3	0.1 ± 0.0	Trace	90.2 ± 5.0
β + γT3	0.4 ± 0.0	ND	2.9 ± 0.6
α ± 3	0.3 ± 0.1	ND	ND
Total (T + T3) mg/100g	4.4 ± 0.8	2.5 ± 0.0	100.1 ± 8.5

Source: Appaiah, 2014

or neutralize free radicals, so it is hoped that the administration of these antioxidants can prevent damage to the body from the onset of degenerative diseases (Zuhra et al., 2008). If this is related to the role of kopyor coconut for health, the role of phenolics is very important as an antioxidant because, according to research by Lerebulan et al., (2018), the highest phenol content is found in deep old coconut at 143.9 mg/kg. According to Appaiah et al. (2014), the oil extracted from coconut has small components such as tocopherols, phenolics, and phytosterols, this is shown in Table 3. The table shows that the antioxidant compounds present in fresh coconut meat are higher than the antioxidant compounds present in fresh coconut meat without testa and testa, or the skin of fresh coconut meat. However, especially for koyor coconut, its antioxidant compounds are still lower than those of whole fresh coconut meat. This is similar to the study by Santoso et al. (1996), which found that specifically for kopyor coconut meat, it contains α tochoferol of 2.34 mg/100g and γ tochoferol of 0.09 mg/100 g of dry matter.

The MCFA mechanism of lauric acid in the body will be converted into monolaurin, MCFA is produced naturally by the body, after coconut oil is consumed it can be absorbed immediately by the intestine, even without pancreatic lipase it can be carried by the portal vein to the liver and will be oxidized quickly into energy (Dayrit & Newport, 2020), monolaurin works by dissolving lipids and phospholipids in the viral envelope which causes the disintegration of the viral membrane (Arora et al., 2011). MCFA specifically have antiviral effects and are useful in reducing disease or preventing HIV disease (Dayrit, C, 2000). Lauric acid can significantly reduce fasting blood sugar, when fresh coconut is consumed it will help reduce blood glucose levels and body weight in normal healthy people (Vijayakumar et al., 2018). MCFA have benefits in skin care, hair care, immunomodulatory effects, cardiovascular, and have recently been used to prevent Alzheimer's disease (Mirzaei et al., 2018), and have fat-lowering properties (Nevin & Rajamohan, 2008). Medium chain fatty acids differ from long chain fatty acids in that they help protect against heart disease. MCFA has been reported to reduce the risk of atherosclerosis and heart disease (C. S. Dayrit, 2003).

PROCESSED KOPYOR COCONUT AND ITS STORAGE

Kopyor coconut flesh can be consumed in fresh form and can be used as a raw material for ice cream (Balitpalma, 2019). In general, in Indonesia, kopyor coconut is consumed in its fresh form or in processed forms such as ice cream, cocktails, and coconut cakes (Agrikan, 2020). Kopyor coconuts in the Philippines are called Makapuno, which can be used as ice cream, candy, bottled syrup, and traditionally in delicacies such as mazapan and sweets (Islam et al., 2013). According to Kumar et al. (2015), the main fiber reported in Makapuno is pectin, while normal coconut is hemicellulose. This pectin is perfect for making jams and candies. Pectin content is very high at 22.36% (Gunathilake et al., 2009). In addition, Makapuno is quite popular as a sweetener and flavoring agent in pastries and ice cream. Kopyor coconut meat can also be made into velva kopyor, namely as a frozen dessert with a low fat content (Farhaniah, 2019).Then, for storage, so that the quality of kopyor coconut meat is maintained, the harvested fruit must be packed in bags, which are then stored at 5 °C during shipping so that they can last up to 6 weeks (Luengwilai et al., 2014). In addition, kopyor coconut meat can be stored at 5 °C using polyamide plastic packaging so that it can last up to 27 days (Antu et al., 2014). The cold storage and packaging approach has been widely used to ship to long-distance markets such as Europe and the United States.

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Photo by Biko Wesa (Kenya), World Coconut Day Competition

Genomic architecture of coconut tree; drought tolerance increasing to expand coconut cultivation for food security in West Africa

Jean Louis Konan Konan[1], Doubi Tra[1], Muriel Joëlle Djeya Okoma[1], François N'klo Hala[1] and Vincent Savolainen[2]

Global climate change through drought is affecting agricultural production and food security worldwide. This situation significantly affects small-scale farmers who depend to crops cultivating. Among crops affected, there is coconut palms (Cocos nucifera) which is planted in Africa, Asia, Latin America and the caribean. Therefore, the present studies which started in 2020 in collaboration between CNRA, Marc Delorme research Station at Côte d'Ivoire and the Imperial college of london, UK aims to identify the drought tolerance coconut trees among genotype available.. To achieve this, nuts production and climatic data collected and recorded 30 years ago at the Marc Delorme Coconut Research Station, which hosts the international genebank for Africa and the Indian Ocean, are used to unravel the genomic architecture of drought tolerance. Data from 24 hybrids planted into 8 experiments plots are choosed to reveal genomic variation associated with drought tolerance. Once drought periods were selected, drought resistance of trees was assessed by investigating the performance of trees through fruit production after a drought periode. To select the trees that performed in the upper quartile (drought resistant palms) and lower quartile (drought susceptible palms), the distribution of the percentage of fruit yield reduction was recorded for all trees. From data already analysed and using measure of drought, there is evidence in 2001 a large reduction of fruit yield in more than 95% of trees, likely the result in 1998. After verification of drought resistant and susceptible trees , the following steps is to collect samples and their processing for identification genotypes correlating with drought resistance gene. These activities lay

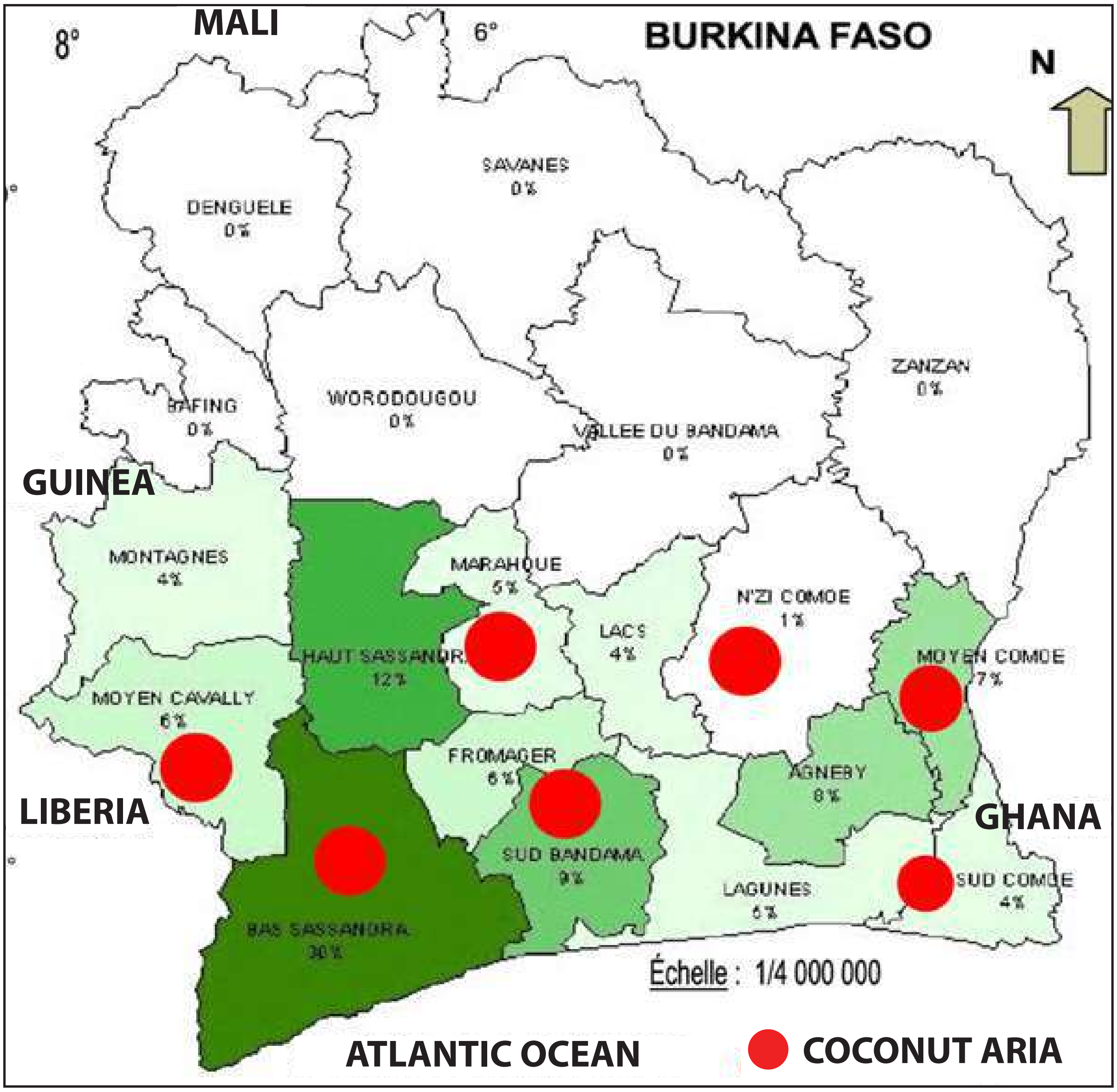


Figure 1. Map of Côte d'Ivoire country map with distribution of coconut plantations.

the foundation of breeding and selection programs to enhance coconut resilience, allowing the crop to be grown into wider range of soils and mitigating impacts of climate change.

OVERVIEW AND OBJECTIVES

Global change through drought affect crop production and food security worldwide. Among the crops affected by climage change there is coconut which cultivated on several continents (Africa, Asia, Latin America and the Caribean). The impact of drought affected smallholder farmers, who rely on local crops. To response to that, studies are implemented by Marc Delorme Research Station in colloboration with Imperial college of London, UK to identify drought tolerance coconut palms in harsh tropical climates in West Africa. Furthermore, results obtenained will contribute to increase small-scale farmer income through implementing principles of circular economy, using tolerante material.

At the central ou north region of Côte d'Ivoire (Figure 1), like in many countries of West Africa and around the world, coconut cannot be growed everywhere due to drought. Coconut growing is not profitable if annual raining is under 1,500 mm and total deficit water over 150 mm (three month successive). So coconut in Côte d'Ivoire is growing into the south and some part of Est region. The soil is not a problem for growing coconut at Côte d'Ivoire.

Table 1. Inventory of the plots and coconuts trees involved in the studies at Marc Delorme Station Côte d'Ivoire

Plots	Year of planting	Age	Number of tree
022	1986	27	1,326
084	1992	29	977
034	1998	23	1,352
023	1988	33	1,250
023	1995	26	279
051	1995	26	355
052	1997	24	676
Total			**6,215**

Figure 2. Three-headed Malayan Tall in Marc Delorme Agricultural Research Centre

At Marc Delorme Research Station many experiments are conducted to create high producer coconut material, develop technologies to support coconut growing. So agromorphometric parameters including seednuts production and climatic data are regularly collected. Marc Delorme station hosts the international coconut genebank for Africa and Indian Ocean which is one of the five international coconut genebank established by FAO and Bioversity International.

Therefore, the present studies which started in 2020 in collaboration between CNRA, Marc Delorme research Station at Côte d'Ivoire and the Imperial college of london, UK aims to identify drought tolerance coconut trees.

PLANT MATERIEL

The total of 6,215 coconut trees from seven plots of Marc Delorme Research Station over 20 years old are involved into the stady. The number of trees used by plot depended to availability of data and phyisical observation (Table 1). The total number of hybrids covered is 24 types of genotypes (Table 2).

METHODS

Identification of drought years

Drought periods were first identified from available climatic data collected over than 20 years and based on a minimum annual rainfall of 1,500 mm. Under this level of raining, the year is considered as drought year. Generally this typ of year cumulated deficit water over than 150 mm on three successive months during the year.

Identification of drought resistant and susceptible trees

Once drought periods were selected, drought resistance trees was assessed by investigating the performance of trees through seednuts production after a drought year. To be able to select the trees that performed in the upper quartile (drought resistant trees) and lower quartile (drought susceptible trees), the distribution of the percentage of yield reduction was evaluated for all trees. Trees that are in the **lower quartile of reduction were identified as drought resistant** and trees that located upper **quartile of reduction were identified as drought susceptible**. Percentage reduction was assessed taking the mean annual yield for each tree, year before for the year of the drought and calculating the proportion that fruit yield was reduced by year after the drought .

Table 2. Composition of Antioxidant Compounds in Fresh Coconut Meat

No.	Genotyps	Signification
1	(WAT×TAT)×RIT	(West African Tall × Tahitian Tall) × Rennell Island Tall
2	CRD×WAT	Cameroon Red Dwarf×West African Tall
3	KKT×RIT	Karkar Tall × Rennell Island Tall
4	KPDT×RIT	Kappadam Tall × Rennell Island Tall
5	KPDT×WAT	Kappadam Tall × West African Tall
6	LMT×(WAT×RIT)	Laccadive Micro Tall× (West African Tall × Rennell Island Tall)
7	MYD×VTT	Malayan Yellow Dwarf × Vanuatu Tall
8	MYD×WAT	Malayan Yellow Dwarf × West African Tall
9	RIT×MPT	Rennell Island Tall × Mapanget Tall
10	RIT×SAT	Rennell Island Tall × Sawarna Tall
11	RIT×IDT	Rennell Island Tall × Igo-Duku Tall
12	RIT×LMT	Rennell Island Tall × Laccadive Micro Tall
13	RIT×WAT	Rennell Island Tall × West African Tall
14	SLT×RIT	Sri Lanka Tall × Rennell Island Tall
15	SLT×WAT	Sri Lanka Tall ×West African Tall
16	TAT×RIT	Tahitian Tall × Rennell Island Tall
17	TAT×WAT	Tahitian Tall × West African Tall
18	VTT×LMT	Vanuatu Tall × Laccadive Micro Tall
19	WAT×MPT	West African Tall× Mapanget Tall
20	WAT×SAT	West African Tall× Sawarna Tall
21	WAT×IDT	West African Tall× Igo-Duku Tall
22	WAT×LMT	West African Tall × Laccadive Micro Tall
23	WAT×TAT	West African Tall × Tahitian Tall
24	WAT×VTT	West African Tall×Vanuatu Tall

To ensure that the observed phenotypic response to drought is the likely result of genotypic expression, trees will be identified in many drought years as possible and final trees will be selected based on trees cross-validated from the drought tolerant and susceptible trees from other drought periods.

Collection and processing of samples

Palm leaf samples (1 g) are collected from selected drought resistant and susceptible trees (850 samples from both) and stored in 2000 ul of RNAlater for processing. The samples are then transported to the laboratory at Imperial College London, where they are extracted for genomic DNA using a QIAGEN Plant Mini DNA extraction kit. The DNA is then sent for low coverage sequencing, which means that only a small portion of the genome is sequenced. This is done to save time and money, while still providing enough data to identify genes that are associated with drought resistance. The sequenced DNA is then aligned to the reference genome for *C. nucifera*, which is the

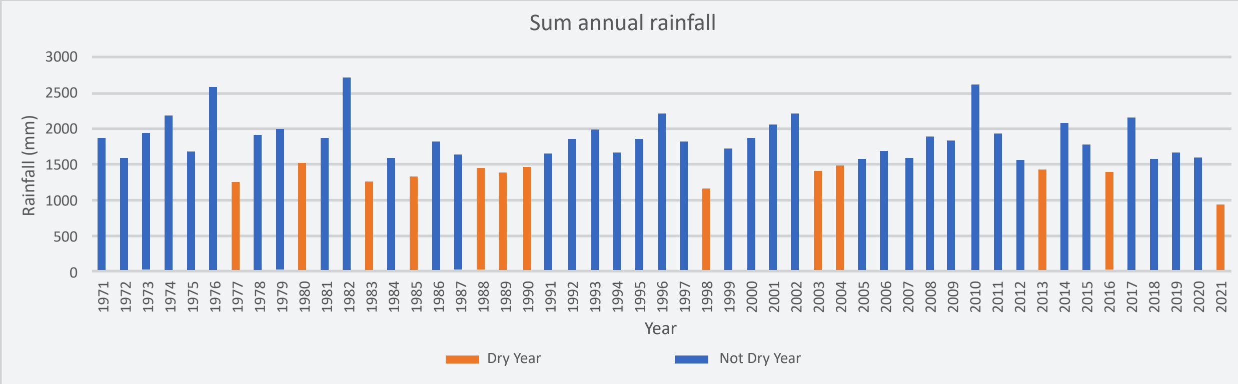


Figure 3. Annual rainfall for the last 50 years at Marc Delorme Station, Côte d'Ivoire Identification of drought susceptible and drought resistant trees.

genome of a drought resistant oil palm tree. This allows the researchers to compare the genomes of the drought resistant and susceptible trees and identify the genes that are responsible for the difference in drought tolerance.

RESULTS

Drought periods from 1971 to 2021

The total of 13 Years with a sum rainfall less than 1,500 mm were identified as drought years regarding the Figure 1. For the others 37 years, raining full was over 1,500 mm, so no negative impact on the yield (number of seeds produced).

IDENTIFICATION OF DROUGHT SUSCEPTIBLE AND DROUGHT RESISTANT TREES

Base on the data collected, there is evidence that in 1988 and 2003 a large reduction of yield is observed on more than 95% of trees for two plots available (Figure 2a), likely with the result of the identified drought in 1998 (Figure 1). This inference is also supported by the relative low fruit yield in 1988 and 2003 for the plots involved (Figure 2 a, b). Based on the distribution of percentage of loss of production for plot 022 and 023 in1988 and 2003, 151 trees were identified in the upper quartile (drought susceptible) and 228 were identified in the lower quartile (drought resistant) (Figure 3 and table 3). Based on this metric, drought susceptible and drought resistant trees were identified in each plot. It comes out from the total 6215 studies tree that 296 are susceptible trees and 493 are tolerants. The number of susceptible and tolerant trees is variable depending to plot for all the dry year.

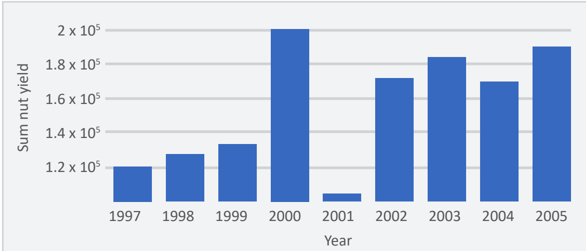


Figure 4. Annual fruit yield for Plot 022 in 1988.

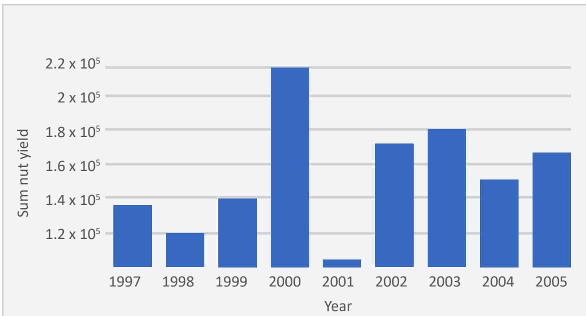


Figure 5. Annual fruit yield for Plot 023 in 1988.

IDENTIFICATION OF GENOTYPES CORRELATING WITH DROUGHT RESISTANCE

Drought resistance SNPs will be identified by carrying out genome wide analysis to find correlations between genomic mutations shared among designated drought resistant trees but not present in trees designated as drought susceptible. To assess the predictive capabilities of the drought resistant associated SNPs identified, an additional set of trees will be used for Genome Prediction; For that fifty (50) drought tolerant trees and another 50 drought susceotible will be used. These trees will not be included in the initial sequenced trees and will be sequenced individually at higher coverage (10x) at Imperial College of London Laboratories.

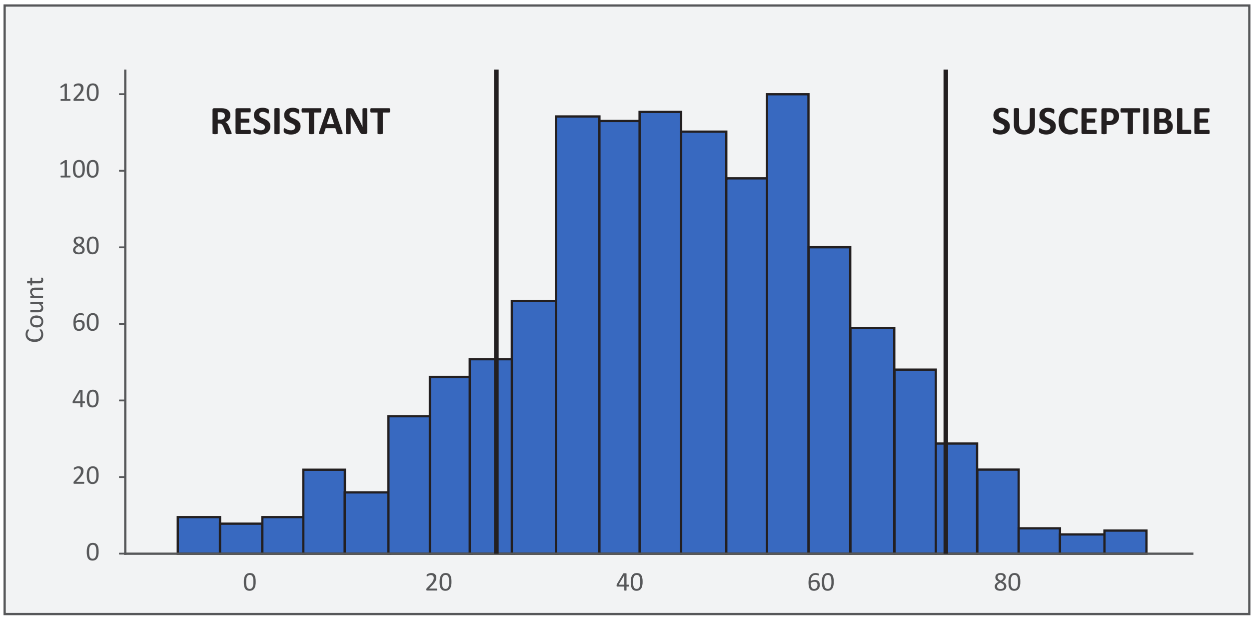


Figure 6. Distribution of percentage change of fruit yield recorded on plots at Marc Delorme research station in Côte d'Ivoire.

Table 3. Number of susceptible and tolerant coconut trees per plot at Marc Delorme Station from 1971 to 2021.

Plot/year of planting	Number of trees analyzed	Number of susceptible trees	Number of tolerant trees
084_1992	977	43	70
051_1995	355	16	22
023_1996	279	4	18
023_1986	1250	73	107
022_1986	1326	78	111
052_1997	676	35	81
034_1998	1352	47	84
Total	**6215**	**296**	**493**

The pooled sequence data will then be used to train a genomic prediction model and those 100 trees will serve as test population for cross-validation. Already, sample of 6215 trees are collected, packed and transferred to London Lab. DNS extracting is going on for sequencing.

CONCLUSION

To select drought tolerant coconut tree, meteorological data collected were recorded. These were used to analys the yield of experimental plots. After analys, coconut trees wich are tolerant or susceptible to were identified. Leaf samples from the 6215 trees involved into the studies where collected. From this total they are 493 tolerant trees and 296 susceptibles.

Identification of drought associated SNPs is going on for breeding programmes to be set up. Tolerant genotyp will enhance the resilience of coconut by growing it on a wider variety of climate where rainfull is limited. It is an opportunity for reducing land conflicts and mitigating the impacts of climate change in Côte d'Ivoire and West Africa.

[1] *National Agronomic Research Centre (CNRA), 01 BP 1740 Abidjan 01, Côte d'Ivoire*
[2] *Vincent Savolainen, Imperial College of London, N.1-17, Ground Floor, Munro, Silwood Park, Buckhurst Road, Ascot, SL57PY, UK*

Engineer Uses Zero-Waste Farming to Make Products With All Parts of Coconuts, Earns Lakhs

Tina Freese[1]

A common sight in most South Indian states are coconut trees, which not only make the environment cleaner, but also provide us with fibrous fruit. And in turn, these fruits have a host of benefits — its oil hydrates our skin and hair, makes our food tastier, and its water quenches our thirst.

The best part about coconuts is that they're a full package. From its shell to its husk, everything has its own use. And a Bengaluru-based startup has found a way to use its goodness to help women and farmers, while earning revenues of Rs 4 lakh per month.

With his startup Tengin, which means coconut in Kannada, 30-year-old Madhu Kargund makes virgin coconut oil, *barfi*, soaps, candle, sugar, chips, crockery shells, coir dish scrubbers, and more.

"I am a farmer's son," says Madhu, "and I have seen how farmers are suffering due to crop failure, lower profits and climate change. I am trying to help them make more profits by converting their coconuts to cash flow."

MAKING COCONUT FARMING PROFITABLE

Born and raised in Arsikere in the Hassan district of Karnataka, Madhu spent his growing years helping his father in the fields.

"Growing up in a farming family, you see the problems farmers face on a daily basis. Firstly, due to climate change and bad rain patterns, growing anything naturally is very difficult. There is no aid

Figure 1. Madhu with his startup Tengin is working with farmers from across Karnataka to make coconut products
Picture credit: Madhu Kargund

for farmers to upskill, and a lack of knowledge about the market results in losses," he says.

Talking about the various problems faced by the farmers, he says, "If I go to the village and start growing tomatoes on my field and get a good price for it, every other farmer in the village would start doing that. This creates a demand and supply imbalance and no one makes a profit. The farmers lack this knowledge and lose profits."

Madhu says that while he always wanted to do something to eliminate these problems, his father wanted him to pursue a stable job. "No farmer would want his sons to join farming because of the losses," he opines.

After completing his Master of Computer Applications, he worked for eight years as a software engineer before deciding to quit his career and start Tengin in 2018.

"Even when I was working as an engineer, my mind was occupied with the thought of how I was not doing what I was supposed to do. I kept ideating different ways in which we can change the current situation. The best way to increase revenue was to eliminate middlemen and source directly from the farmers so they get more margin," he says.

By 2018, Madhu was sure that a 9 to 5 was not his calling. When Madhu decided he wanted to start a business that helps the farmers, he knew where to turn to — coconuts, which he had seen his father grow all his life. The beginning of his venture came about while he was still working in engineering, when he decided to make batches of virgin coconut oil.

"It was in 2020, that I decided to throw myself completely into the business and quit my job," he says.

NATURAL, SUSTAINABLE AND WASTE-FREE

When Madhu decided to quit his job, his decision did not get the reception he was hoping for.

"My parents did not want me to do agriculture. He did not want me to become a farmer, he wanted me to continue my job. Agriculture is one of the most difficult jobs in the world, and farmers don't get enough money or respect for it," he shares.

Even though there was resistance from the family, Madhu was set in his ways. To make farming more profitable in his village, he figured out a way of farming called zero-budget natural farming with multiple crops.

"Most of the villagers in my village practised single farming or mono-crop farming, But in the other

Figure 2. Madhu Kargund makes virgin coconut oil, barfi, soaps, candle, sugar, chips, crockery shells, coir dish scrubbers, and more
Picture credit: Madhu Kargund

method, you grow multiple crops at the same time. For instance, in between coconut, you can plant areca nuts, in between areca nuts you can plant bananas, and in between them, tomatoes. This way, farmers produce a variety of plants on the same piece of land," he says.

While conceptualising Tengin, Madhu decided to engage women SHGs in his village to make the products.

"There are many *sanghas* (women groups) in the villages, which I decided to engage with. They make a variety of products and we keep innovating to produce zero-waste from the coconuts. The coconuts are sourced from farmers in my village and some from other districts of Karnataka," he says.

Madhu works with more than 20 farmers in Karnataka and Goa, along with nearly eight women from SGHs in his village to make the products.

"We buy directly from the farmers, eliminating any cost of transportation on their part and any middlemen at fair prices, so that they get more profit margins," he explains.

"We keep innovating with our products. While I started off with just virgin coconut oil, we have advanced into various other products, from soaps, scrubs to crockery. During Diwali, we made coconut *diyas*, and during Raksha Bandhan, we made coconut shell *rakhis*," he says.

"The coconut shells are mostly thrown away, but I thought that they could be a sustainable replacement for plastic cups and mugs. From the coir, another waste product, we made dishwashing scrubs. We made use of the residual coconut powder, which comes after we extract the oil to make coconut rocher, mixing it with dark chocolate," he says, adding that all the coconuts used in the production are grown naturally.

Vani Murthy, a customer of Tengin, says, "Coconut products are so intrinsic to our culture and traditions in South India. Coconut oil is a multipurpose product that we use daily in our homes, be it for cooking, or as personal care. Tengin is one such authentic brand that I reach out to for my needs. All their products are amazing and I love the fact that this brand supports local livelihoods too. They are constantly bringing out interesting new products from coconut."

Madhu says he started by making 150 ml of virgin oil, and today has sold over 500 litres. On average, the company makes a revenue of Rs 3 to 4 lakh a month.

"For me and Tengin as a company what we want to do is bring into light the story behind our brand. It is not just the products we are selling but the farmers

Figure 3. During Diwali, the company made coconut diyas, and during Raksha Bandhan, they made coconut shell rakhis.
Picture credit: Madhu Kargund

who work hard's story we are narrating too. I go to flea markets and talk to my customers, educating them about where the products are coming from, and how are they made. By buying them, they are not just buying the products but also helping the farmers," he points out.

As for the future, Madhu wants to keep expanding and innovating new products made out of coconuts.

"Whenever we talk about innovation or upskilling, it is always sectors like IT that we want to focus on. There is almost a negligible amount of conversation around upskilling farmers and updating them with the latest technology. We are already in the middle of a migration crisis with most of the youth moving out of farming in search of better job opportunities. With my startup, I can only hope to make the profession more profitable and appealing to the youth to carry on doing farming," reflects Madhu on his journey so far.

Figure 4. One of products of Tengin
Picture credit: Tengin's Instagram

[1]*Agriculture Journalist, The Better India*

Experts' Finding on the Health Benefits of Coconut

Dr. Fabian M. Dayrit
Chairman of ICC Scientific Advisory Committee on Health and Professor, Department of Chemistry, Ateneo de Manila University, Academician, National Academy of Science and Technology and President, Integrated Chemists of the Philippines

Virgin coconut oil is effective in lowering C-Reactive Protein levels among suspect and probable cases of COVID-19. There were two main indicators used: recovery from COVID-19 symptoms and level of C-Reactive Protein (CRP) in the blood. These two indicators showed that VCO can be used to treat mild COVID-19 cases.

CRP is a protein that is analyzed in the blood as a quantitative measure of inflammation or infection. CRP level less than 5 mg/L indicates recovery from inflammation or infection. The recovery from COVID-19 symptoms was more rapid in the VCO group compared with the Control group: 17% in the VCO group showed improvement compared to only 4% in the Control group. Full relief from COVID-19 was attained by day 18 in the VCO group compared to day 23 in the Control group.

The level of CRP in the VCO group dropped much more rapidly and completely compared to the Control group. By day 14, the CRP level in the VCO group had fallen below the 5 mg/L, and this continued to show a decreasing trend at day 28. In comparison, the CRP level in the Control group fell slowly to 5 mg/L at day 14 and stayed at this level until day 28.

Other beneficial effects of VCO were noted from the blood assay:

- HDL-cholesterol ("good cholesterol") increased
- LDL and triglycerides remain within normal range
- Fasting blood sugar (FBS) decreased

These results show that VCO, indeed, is a healthy oil.

Source: Proceedings of the XLIX Cocotech Conference, 30 August-2 Sept 2021, Jakarta, Indonesia.

Dr. Faizal C. Peedikayil
Professor & Head Department of Pedodontics & Preventive Dentistry, Kannur Dental College, India

Coconut oil rinsing reduces gingival inflammation. Oil rinsing is a type of traditional procedure that involves swishing edible oil in the mouth and then spitting it out. Virgin and regular coconut oil can be used to reduce plaque related gingivitis. However, the study shows that virgin coconut oil has better taste, odor, and texture in the mouth than regular cooking coconut oil. The advantage of coconut oil or virgin coconut oil as natural oils is that they neither cause any staining as seen in the use of mouthwashes nor there is any after taste or allergic reactions. and are readily available. Such practices cure about 30 systemic diseases and have an effect on the overall well-being of the individuals practicing it.

Source: CORD Journal, Vol. 37 2021

Experts' Finding on the Health Benefits of Coconut

DR. D. P. Athukorale
Cardiologist, Pharmacologist, Academician, Colombo, Sri Lanka

Green Coconut has much water and is rich in proteins, minerals, vitamins, calcium, phosphores, iron, iodine, chlorine, sulphur, potassium, carbohydrates and vitamins, B1, B2, B5 and magnesium. The water also helps the hydration of the body. The green coconut has a ratio of amino acids arginine, alanine, cisteína (essential) and serina, greater than those found in cow's milk. It is perfect and natural isotonic to restitute energies in the human body.

Tender coconut water has been used in other areas of the world where intravenous solutions cannot be obtained. Japanese have used tender coconut water (T. C. W.) intravenously in Sumatra, Indonesia in World War I. Pradera et. al. have used intravenous T. C. W. for pediatric patients in Havana, Cuba without any serious reactions.

Source: Dr. D.P. Athukorale 2008. Tender Coconut Water – Its Health Benefits Cocoinfo International, 15 July: 14-16

Prof. Dr. Rabindarjeet Singh
Lifestyle Science Cluster, Advance Medical and Dental Institute, Universiti Sains Malaysia, Bertam 13200 Kepala Batas, Penang, Selangor, Malaysia

Coconut water (*Cocos nucifera* L.) is an ancient tropical beverage whose popularity has been increasing in recent years. This 'naturally canned' beverage is a sweet refreshing drink obtained directly from the inner part of the fruit. It is a beverage that has drawn the attention as a natural functional drink. Coconut water is sterile at source, and is very rich in potassium, and contains sodium, chloride, magnesium and carbohydrates. Therein, making it a healthier alternative to carbonated drinks including isotonic sports drinks. Apart from the lower calories due to lower sugar content, the non-carbonated coconut water is also a great source for replacing the electrolytes lost during sweating when compared to carbonated drinks. Ingestion of carbonated drinksis known to be associated with gastrointestinal discomfort in certain individuals. This "Mother Nature's" gift of coconut water, could be prized as the beverage above all other beverages for its health renewing properties.

Source: Proceedings of the XLVI Cocotech Conference 7-11 July 2014, Bandaranaike Memorial International Conference Hall Colombo, Sri Lanka.

Experts' Finding on the Health Benefits of Coconut

Dr. (Mrs.) E.R.H.S.S. Ediriweera
Senior Lecturer, Department of Nidana Chikithsa, Institute of Indegenous Medicine, University of Colombo, Rajagiriya, Sri Lanka

- Young coconut water could be drunk to alleviate the burning sensation during micturition
- Young coconut water, breast milk, treacle of *Saccharum officinarum* (*F. Graminae*) and sugar are mixed together and given for hiccough
- Leaves of *Dregia volubilis* (*F. Asclepiadaceae*) are to be pounded and mixed with tender nut water. The juice is extracted and given in treatment of poisoning of *Nerium indicum* (*F. Apocyanaceae*)
- Water of young king coconut (before flesh is formed inside) is given for fever and it can be consumed as a diuretic in dysuria.
- A King coconut is to be opened by slicing off the top.30 gms of powdered fruits (without seeds), of *Terminalia chebula* (*F. Combretaceae*) are added to the King coconut water inside and stirred. Sliced top is then replaced (as a cover) and kept outdoors in the dew overnight. Following morning, the mixture inside is to be filtered and drunk as a purgative. This is called El Vireka by Sri Lankan traditional physicians. The number of bowel motions will increase as the person continues to drink cold water from time to time during the morning. He should not consume hot or warm food and liquids. This is good for purifying blood and cooling the body.

Dr. Faizal C. Peedikayil
Professor & Head Department of Pedodontics & Preventive Dentistry, Kannur Dental College, India

Coconut oil rinsing reduces gingival inflammation. Oil rinsing is a type of traditional procedure that involves swishing edible oil in the mouth and then spitting it out. Virgin and regular coconut oil can be used to reduce plaque related gingivitis. However, the study shows that virgin coconut oil has better taste, odor, and texture in the mouth than regular cooking coconut oil. The advantage of coconut oil or virgin coconut oil as natural oils is that they neither cause any staining as seen in the use of mouthwashes nor there is any after taste or allergic reactions. and are readily available. Such practices cure about 30 systemic diseases and have an effect on the overall well-being of the individuals practicing it.

Source: CORD Journal, Vol. 37 2021

Bearish Market of Coconut Oil in the Second Half of 2023

Alit Pirmansah[1]

Lauric oils experienced a historic price hike in March 2022, followed by a steep drop to the lowest level in October 2022, recording a decrease of over 50% in just six months. The prices in October 2022 were the lowest since November 2020. The price constantly weakened during the first half of 2023 as demand in Europe and US dropped due to the economic slowdown in regions. With expected weaker demand, lauric oil prices are set to depreciate or at least maintain the current trend in the second half of 2023. On average, from June to December 2023, prices of palm kernel oil are forecasted to be around US$960/MT, while coconut oil prices are projected to be at US$1,060/MT.

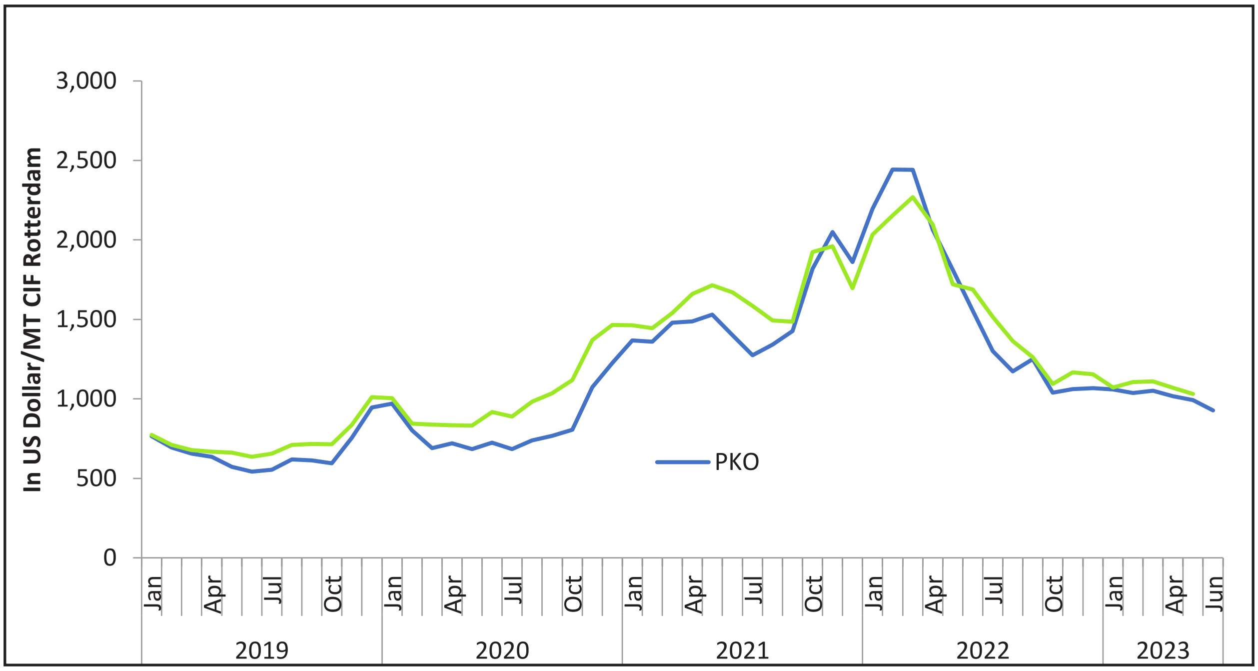
The global production of lauric oils is anticipated to decrease marginally in 2023, with a projected output of 11.39 million tons, compared to 11.46 million tons in

Table 1. Coconut Oil Production, 2021-2023 (000MT)

Countries	2021	2022	2023e
Philippines	997	1,314	1,078
Indonesia	777	883	865
India	366	360	373
Mexico	132	132	131
Sri Lanka	58	67	65
Malaysia	53	55	56
Vietnam	40	41	41
Papua New Guinea	39	45	43
Thailand	29	29	29
Other countries	**263**	**268**	**259**
World	2,754	3,194	2,940

Source: Oil World and ICC estimates

Bearish Market of Coconut Oil



Source: ICC

Figure 1. Price Trend of Lauric Oils, January 2019-December 2022 (USD/MT)

the previous year. This decline is primarily attributed to a substantial drop in coconut oil production. Producers in the Philippines and Indonesia are expected to witness a decrease in output due to exhausted coconut trees following high yields in the preceding two years, coupled with ample rainfall.

The world production of coconut oil is forecasted to contract by over 240 thousand tons in 2023. The Philippines, one of the leading producers, is expected to witness a significant decline, with its production plummeting to 1,078 tons, representing a year-on-year drop of more than 236 thousand tons. Similarly, Indonesia, another major producer, is projected to experience a decline in production, from 883 thousand tons in 2022 to 865 thousand tons in 2023.

In contrast to coconut oil, palm kernel oil production is anticipated to increase by 181 thousand tons in 2023. The largest palm kernel oil producers, Indonesia and Malaysia, are expected to bolster their output, with Indonesia projected to produce 4.92 million tons and Malaysia reaching 2.16 million tons in 2023.

Table 2. Palm Kernel Oil Production, 2021-2023 (000MT)

Countries	2021	2022	2023e
Indonesia	4,653	4,835	4,920
Malaysia	2,049	2,097	2,159
Thailand	282	294	296
Nigeria	151	163	167
Other countries	840	878	906
World	7,975	8,267	8,448

Source: Oil World and ICC estimates

The projected decline in lauric oil production is likely to affect the global import demand for these oils. Specifically, coconut oil imports are expected to decrease by at least 311 thousand tons in 2023. European countries' imports of coconut oil are projected to dwindle by more than 81 thousand tons, while China's import demand is forecasted to reduce by over 11%. Furthermore, the US market is expected to experience a decline of 75 thousand tons in its coconut oil import demand.

Table 3. Coconut Oil Imports, 2021-2023 (000MT)

Countries	2021	2022	2023e
EU-27	616	691	610
USA	468	535	460
Malaysia	225	360	287
China	174	219	195
UK	27	24	26
Other countries	**489**	**518**	**458**
World	1,999	2,347	2,036

Source: Oil World, and ICC estimates

Table 4. Palm Kernel Oil Imports, 2021-2023 (000MT)

Countries	2021	2022	2023e
EU-27	713	600	675
USA	382	348	380
China	628	535	610
Malaysia	286	252	290
Brazil	248	230	250
Other countries	**1,083**	**978**	**1,114**
World	3,340	2,938	3,319

Source: Oil World, USDA, and ICC estimates

The high price premium of coconut oil relative to palm kernel oil is likely to drive a shift in demand toward the latter. Consequently, the import demand for palm kernel oil is estimated to increase by 75 thousand tons in European countries, 32 thousand tons in the US market, and at least 75 thousand tons in China, resulting in a global demand rise of 381 thousand tons in 2023.

The expected decline in coconut oil production may lead to a curb in world consumption. Both global exports and domestic consumption of coconut oil are estimated to decrease in 2023. Exports of coconut oil are expected to drop by around 245 thousand tons, and domestic consumption is projected to weaken by 184 thousand tons. Nevertheless, these effects are likely to be mitigated to some extent by reductions in stocks, with global coconut oil stocks expected to reduce by approximately 495 thousand tons.

The global lauric oils market is poised for a dynamic year in 2023, with projected declines in coconut oil production, compensated by increased palm kernel oil output. Shifts in demand patterns are expected due to price differentials between the two oils. Market players must closely monitor these trends to adapt their strategies and optimize their positions in this ever-evolving industry.

[1] *Market and Statistics Officer, International Coconut Community*

Table 5. World Balance of Lauric Oils (000MT), 2022-2023

Countries	Coconut Oil		Palm Kernel Oil		Lauric Oils	
	2022	2023e	2022	2023e	2022	2023e
Beginning Stocks	370	440	1,340	1,350	1,710	1,790
Production	3,194	2,940	8,267	8,448	11,461	11,388
Imports	2,347	2,036	2,938	3,319	5,285	5,355
Total Supply	5,911	5,416	12,550	13,120	18,461	18,536
Exports	2,313	2,068	3,191	3,292	5,504	5,360
Domestic Consumption	3,178	2,994	7,892	8,384	11,070	11,378
Ending Stocks	420	354	1,467	1,444	1,887	1,798
Total Distribution	5,911	5,416	12,550	13,120	18,461	18,536

Source: Oil World, USDA, and ICC estimates

INTERNATIONAL CONFERENCE ON TRADE AND MARKETING OF COCONUT PRODUCTS

The International Coconut Community (ICC), in collaboration with the Coconut Development Board (CDB) of India, organized a two-day International Conference on Trade and Marketing of Coconut Products. Held at Le Meridian Hyderabad, Telangana, India, from February 27-28, the conference adopted a hybrid mode to accommodate both physical and virtual participants. With the theme ***"Global Coconut Industry – Cruising to the Pinnacle"***, the conference aimed to facilitate knowledge-sharing, discuss market trends and challenges, explore research areas, and devise strategies for sustainable development in the coconut sector.

The event brought together renowned speakers, experts, entrepreneurs, policymakers, and officials from countries such as India, Indonesia, Philippines, Sri Lanka, Thailand, Malaysia, Germany, the Netherlands, and Switzerland. Over 125 participants attended in person, while more than 400 participants joined virtually. The conference provided a platform for stakeholders in the coconut community to share insights, discuss the international outlook for coconut products, and collaborate on strategies and policies that benefit both farmers and the industry.

The conference commenced with a formal inauguration on February 27, featuring esteemed dignitaries who lit the traditional lamp. Among the notable figures present were Shri. Raghu Nandan Rao, Agriculture Production Commissioner and Secretary to Government, Department of Agriculture, Government of Telangana; Dr. Jelfina C. Alouw, Executive Director, International Coconut Community; Dr. N. Vijaya Lakshmi, Chief Executive Officer, Coconut Development Board; Mr. Bernie Ferrer Cruz, ICC National Liaison Officer & Administrator, Philippine Coconut Authority; and other prominent individuals in the field. During the inaugural session, the 75-year diamond jubilee issue of the Indian Coconut Journal was released, and plaques of appreciation were exchanged.

The workshop comprised four sessions over two days. The first session, "International Outlook for Coconut Products," focused on global market prices. The second session, "Moving Towards Sustainable Coconut Sourcing," explored strategies to achieve sustainable sourcing and overcome trade barriers. The third session, "Global Market Prospects and Growth," provided industry stakeholders an opportunity to share their experiences and discuss collaborative actions for new market development. The final session, "Innovative Industry Practices and Technology Applications in the Coconut Sector," delved into coconut good agricultural practices, digital marketing, blockchain technology, and industry-farmer partnerships.

Each session was followed by open forums and discussions in which researchers, extension officers, stakeholders, industry representatives, and farmers actively participated, both in-person and virtually. The conference concluded on February 28 with a formal valedictory session addressed by Dr. N. Vijaya Lakshmi, Chief Executive Officer of the CDB, and Dr. Jelfina C. Alouw, Executive Director of the ICC. The two-day conference was skillfully moderated by Mrs. Deepthi Nair, Director (Marketing) at the Coconut Development Board. *(ICC News)*

VAIGA 2023 –DEVELOPING VALUE CHAIN IN AGRICULTURE

The Department of Agriculture, Government of Kerala, India, organized the 6^{th} Edition of VAIGA-2023-Developing Value Chain in Agriculture from 25^{th} February to 2^{nd} March at Thiruvananthapuram, the capital of Kerala, India. VAIGA 2023 is a mega event of the Department of Agriculture and an initiative for Agri growth in the state. It is at the forefront of developing and modernising the agriculture sector since 1908. The department works at the grassroots through Krishi Bhavans, guiding and supporting farmers via institutions like Vegetable & Fruit Promotion Council Kerala (VFPCK), State Horticulture Mission (SHM) Kerala, and Small Farmers Agri-Business Consortium (SFAC) Kerala, Kerala Agricultural University and PSUs in Agricultural Sector.

The week-long program was formally inaugurated on 25^{th} February by Hon'ble Chief Minister of Kerala Sri. Pinarayi Vijayan. The program was presided by Sri. P. Prasad, Hon. Minister for Agriculture, Kerala. An exhibition was also arranged in which 250 stalls were erected and the FPOs, SHGs and farmers exhibited their produces. VAIGA 2023 promoted and encouraged the development of value chains in Kerala's agro sector, improving production levels and encouraging new technologies. The participants included the agriculturists, researchers, universities, Farmer Producer Companies, self-help groups, start-ups, agriculture students, commodity boards and other development and partner organizations.

During the week long program different competitions, B2B meetings, technical seminars and workshops were arranged. In the seminar altogether 18 sessions were organized in which one session was exclusively on Advances in Coconut Production Technologies conducted on 2^{nd} March. International Coconut Community, Jakarta, Indonesia got an opportunity to being part of this big event of Govt of Kerala, India. Dr. Jelfina C. Alouw, Executive Director attended as a key note speaker of the session. She presented on Sustainable Coconut Industry-A Global Perspective & Scenario. The session was inaugurated by Hon'ble Minister of Electricity, Government of Kerala Mr. K. Krishnan Kutty and chaired by Dr. K. B. Hebbar, Director, CPCRI, India and co-chaired by Dr. Hanumanthe Gowda, Chief Coconut Development Officer, CDB, India. Other speakers attended were from CFTRI Mysore, Kerala Agriculture University and private sector entrepreneur. Open discussion and interactive session were conducted in which the queries of the participants were addressed. The other dignitaries attended the session were Dr. B. Ashok, IAS Principal Secretary & Agriculture Production Commissioner, Agriculture Department, Kerala, Dr. P. Rajashekaran, Chairman, State Agricultural Prices Board, Kerala and Chairman of the Seminar Committee and Mr. George Sebastian, Convener of the Seminar Committee. Ms. Mridula Kottekate, Assistant Director, ICC also attended the program.

Mr. P. Prasad, Hon'ble Minister of Agriculture, Govt. of Kerala attended the seminar and distributed plaques of appreciation to the speakers. *(ICC News)*

COURTESY MEETING WITH HONORABLE MINISTER OF AGRICULTURE, GOVERNMENT OF KERALA, INDIA

Got an opportunity to have a courtesy meeting with Hon'ble Minister of Agriculture, Government of Kerala, India Mr. P. Prasad on 3rd March in his office at Assembly Building of Government of Kerala. The meeting was also attended by Dr. B. Ashok, IAS Principal Secretary & Agriculture Production Commissioner, Agriculture Department, Kerala and Dr. P. Rajashekaran, Chairman, State Agricultural Prices Board, Kerala.

There were in detail discussion on different aspects related to promotion of coconut and its value-added products in the state of Kerala. Hon'ble Minister informed about the "Kera Gramam" project of Government of Kerala implemented by the department of agriculture for the coconut development in the state and suggested to develop collaborative programs with ICC mainly on capacity building and exposure visit of the industry stakeholders and coconut entrepreneurs to major ICC coconut growing countries. He requested to Executive Director in exchanging global technology on processing of coconut milk and cream from the ICC member countries like Philippines, Indonesia, Sri Lanka and Vietnam. He also expressed his willingness to attend the next International COCOTECH Conference of ICC in 2024.

Dr. B. Ashok, IAS. Principal Secretary and Agriculture Production Commissioner suggested that ICC can be part of the future VAIGA program of department of agriculture, State of Kerala and in that way more international organizations and speakers can be invited to the program.

Dr. Jelfina C. Alouw , Executive Director, ICC expressed her gratefulness to Hon'ble Minister for inviting ICC to be part of the VAGIA program and also for the opportunity to have a courtesy meeting with him. She assured the full support of ICC for the sustainable development of the coconut sector in the state. She suggested if state of Kerala can adopt the one district one product program of government to promote the value-added products of coconut. She further added that ICC has provided the capacity building webinar series for the Caribbean countries in association with International Trade Centre (ITC) and similarly can plan for the coconut stakeholders of Kerala. Dr. Alouw invited Hon'ble Minister to attend the World Coconut Day celebration 2023 at Gorontalo regency of Indonesia in September. Ms. Mridula Kottekate, Assistant Director, ICC also accompanied the Executive Director.

The meeting concluded with exchange of mementos. *(ICC News)*

COURTESY VISIT TO NATIONAL INSTITUTE OF INTERDISCIPLINARY SCIENCE & TECHNOLOGY (NIIST), THIRUVANANTHAPURAM, KERALA, INDIA

Dr. Jelfina C. Alouw, Executive Director and Ms. Mridula Kottekate, Assistant Director of ICC visited the National Institute of Interdisciplinary Science & Technology (NIIST), Thiruvananthapuram, Kerala, India on 3rd March 2023 and met Dr. Anandharamakrishnan, Director, NIIST and his team of researchers.

Meeting was arranged with some researchers of NIIST from various scientific disciplines. Researchers from the Agro-Processing and Technology, and the Materials Science and Technology divisions presented the different research activities and products developed that is conducted in collaboration with national and international institutions. Dr. Anandharamakrishnan introduced his team and informed that around 80 researchers and 300 Ph.D students are attached with the institute. The institute is providing capacity building to the start-ups and interested farmers and stakeholders and even to the vocational teachers of the schools. The institute has developed different products from the biodegradable wastes including coconut and coir and now looking forward to the commercialization of the products. The campus is maintained fully plastic free Eco-Campus.

The division of Agro-Processing and Technology division already developed the products from neera and virgin coconut oil. They are now working on vegan products developing from coconut milk, cream and MCT oil. Director added that the institute is moving from basic science to applied science and on waste utilisation. Atomization and nutritive aspects of coconut products are their future plan including processing of coconut milk and coconut water.

He expressed his willingness to collaborate with ICC in any capacity building and other research activities related to coconut and its value-added products.

Dr. Jelfina C. Alouw, expressed her gratitude to Director for giving an opportunity to visit him and the institute and acknowledged all support and assistance rendered by Dr. Anandharamakrishnan as a resource speaker in many of the virtual webinar series organized by ICC in association with NAM-CSSTC and ITC. He was also a member of the committee and chaired the meeting called by ICC to finalise the ICC Quality Standards for the various coconut products. She requested the director to assist ICC and to become member of ICC-Scientific Advisory Committee on Health considering his expertise and experience.

There were in detail discussion on different aspects related to the coconut and its value-added products and how to make this sector more sustainable. Dr. Anandharamakrishnan appreciated the initiative taken by ICC in finalising and updating the quality standards of coconut products and assured that he and his team will fully support for the future programs of ICC. He also expressed his willingness to host any of ICC future program in India.

The meeting concluded with exchange of mementos. *(ICC News)*

NELSON DISCUSSES THE COPRA PRICE STABILIZATION STRATEGY WHILE MEETING WITH DELEGATIONS FROM VARIOUS COUNTRIES

Nelson Pomalingo, the Regent of Gorontalo, met with various foreign groups at the Hyderabad, India, foreign Conference on Trade and Marketing of Coconut Products. The meeting, which lasted two days and featured four sessions, addressed topics such as sustainable coconut sourcing, the development of the worldwide market for coconut goods, cutting-edge business practices, and technological uses in the coconut industry. The meeting featured the presentation of 18 technical papers, and more than 450 participants from around the globe registered to participate, including 26 foreign groups.

Nelson Pomalingo, the Chairman of the Coalition of Coconut-Producing Regencies (Kopek) in Indonesia, participated in the international conference and spoke about the future of coconut goods. During the occasion, he had meetings with foreign representatives from different nations.

During the summit, according to Rusthamrin H. Akuba, Special Staff to the Regent of Gorontalo, Bupati Nelson met with foreign representatives from different nations. He first had a meeting with the non-aligned South-South cooperation envoy to go over trade and business possibilities as well as human resource development. The group was verbally invited to the World Coconut Day 2023 in Gorontalo by the Regent during the gathering.

Second, Dr. Julian Conway McGill, Head of South East Asia at LMC International in Kuala Lumpur, was invited to a conference. The conference's main lecturer, Dr. McGill, spoke on the topic of stabilising the price of copra and coconut oil.

Additionally, the Regent Nelson verbally invited Dr. McGill to serve as the main guest at WCD 2023 in Gorontalo. Dr. McGill declared his intention to go.

Thirdly, a discussion with Telangana Provincial Government officials was conducted in Hyderabad. At the gathering, it was debated whether Limboto and Hyderabad could become Sister Cities.

Nelson also took part in a brief talk about methods for stabilising copra prices with a group from the Philippines headed by the Administrator of the Philippines Coconut Authority (PCA). According to the Philippine delegation, copra costs are heavily influenced by rates on the global market. The Philippines implements an Integrated Coconut Farming System and an Integrated Coconut Processing System with a greater emphasis on expanding producers' revenue.

The Gorontalo Regent Nelson Pomalingo received the high-quality copra processing technology from talks with numerous groups and various Indian businesses. More talks must be held to talk about the businesses' financial cooperation, according to Rusthamrin H. Akuba. *(Tatiye ID)*

GLOBAL DEMAND FOR COCONUT OIL FUELS A PUSH FOR OUTPUT IN THE PHILIPPINES

The Philippines, which competes with Indonesia as the world's top supplier of coconut oil, is launching an ambitious plan to increase production in anticipation of growing demand for the product, which is used in food, cosmetics, and biofuels.

According to Bernie Cruz, director of the Philippine Coconut Authority, the government is assisting farmers in planting hybrid coconut seedlings that will grow fruit more quickly and produce two times as much fruit. Following the destruction of Philippine crops by typhoons and pests, the South-East Asian nation wishes to maintain its lead over Indonesia, which is quickly catching up.

The program, which will be carried out from President Ferdinand Marcos Jr.'s administration through 2028, could increase the amount of tropical oil that is provided to the world market. Since March, coconut oil prices have decreased by about 60%, mirroring a decline in competitor palm oil as Indonesia increased shipments. The Philippines' main agricultural product, valued at US$2 billion (RM8.76 billion) in 2017, is coconut oil.

Coconut oil, once regarded as unusual outside of the tropics, is now widely available in shops and natural food stores. It can be used in a variety of ways, including as baking and heating oil, in cosmetics like lipstick and shampoo, and as biodiesel when combined with gasoline.

Cruz anticipates that demand will continue to soar, particularly for goods like pure coconut oil. It will also help that vegan and organic goods are becoming more and more popular as customers turn to plant-based foods and cosmetics for their needs.

According to Yvonne Agustin, ED of business association United Coconut Associations of the Philippines, the Philippines shipped 1.15 million tonnes of coconut oil in 2018, an increase of 31% from 2021. This year, she anticipates a further increase in shipments. The US and Europe receive the majority of the amount.

Yields and production must maintain pace. According to Cruz, each tree in the Philippines yields about 44 coconuts annually, which is less than half the yield in Indonesia and India. Over 3.6 million ha, or 365 million coconut palms, are spread throughout the nation.

In the Philippines, millions of trees were lost as a result of super typhoons and a significant insect epidemic. More than half of the nation's production is produced on the southern island of Mindanao, where the effect was especially devastating. Copra, or desiccated coconut flesh, is used to make oil.

Cruz, who previously held the position of minister for agricultural reform, stated that increasing output is the greatest challenge. "The business needs to be fixed seriously. It continues to be our top-earning farm commodity in terms of dollars," he said in an interview.

By replanting plants and increasing coconut production from seven to four or five years, the goal is to double harvests. The industry is also concentrated on creating higher-value goods, such as "lambanog", a coconut liquor known as the Philippine vodka, and a construction board substance made from coconut husks.

Cruz stated that Unilever Indonesia is also interested in purchasing Philippine coconut sugar for its soy sauce product. We must advance along the value chain, he declared. *(The Malaysian Reserve)*

TWO-DAY COCONUT PRODUCTS CONFERENCE ENDED

An worldwide symposium on the marketing and commerce of coconut products was conducted over two days.

The organisers reported that over 450 delegates from all over the world participated online and that 26 foreign delegates are present in person.

The Coconut Development Board (CDB), the Union Ministry of Agriculture and Farmers Welfare, and the International Coconut Community are organising the meeting. (ICC).

The conference's opening speaker, CEO of the Board Vijayalakshmi Nadendla, noted that according to ICC data from 2020, India is the world's top producer of coconuts with a share of 30.93%, followed by Indonesia and the Philippines. India comes in second place in terms of output, producing 9,346 almonds per hectare, just behind Vietnam, which produces 10,547. The coconut crop generates foreign income of about ₹7,576.8 crore and a GDP contribution of about ₹30,795.6 crore for the nation.

The amount of coconut product exports in 2021–2022 increased from ₹2,294.81 to ₹3,236.83 rupees.

Jelfina C. Alouw, executive director of the International Coconut Council, spoke to the group and emphasised the importance of enabling the transmission of technical knowledge on coconut market forecasts globally, innovative industries in the coconut sector, and sustainability in the coconut sector. *(The Hindu)*

GM BOARD OF THE COCONUT INDUSTRY BELIEVES IN TECHNOLOGY

Shaun Cameron, general manager of the CIB, revealed that the organisation has teamed up with the Geographic Information Systems (GIS) division at the National Works Agency to develop a database that will provide details on the various species of coconuts in Jamaica and indicate where they can be found as well as the soil type required to grow them, among other things.

As he stated to the Jamaica Observer, "We're planning to have that hosted on their external platform," CIB will be "building out our ICT [information and communications technology] infrastructure here because my vision is to have a coconut database that maps the entire island in the meantime."

The general manager described the database as one that would enable producers and anyone else interested in the coconut business to "come on our website and click our geospatial map and be able to bring up the parish they're in". As a result, it will make it easier for people to obtain information quickly, regardless of the gadget they use: a smartphone, iPad, laptop, or personal computer.

Additionally, according to Cameron, the database ought to serve as a hub of information for both domestic and international producers. The GIS section will transfer the technology to the CIB after the database and the GIS mapping activity are finished, and the CIB will then take over as the host of the data.

"Since I have a foundation in information technology and I believe in working better, not harder, I am changing the Coconut Industry Board to a data-driven organization," he said.

The general manager is also considering creating an app especially for the coconut industry, which would be a database expansion and let coconut producers stay informed and in touch with the CIB. The software should specifically aid farmers with proper management of coconut nurseries, teach them how to recognise and treat the deadly yellowing disease that has devastated the industry since the 1970s, and help them distinguish between different kinds of coconut trees.

Cameron stated that he has set aside more than $10 million for the build out when questioned about the CIB's commitment in this technological change project.

He revealed, "We have already invested $5 million at the board, reorganising our infrastructure and recabling [our network], putting in a server room, and purchasing a brand-new computer to house our bookkeeping duties."

He stated that his subsequent action would be to hire programmers to build the app and buy a server with a storage capability of more than 12 terabytes to house the CIB's database. Cameron, however, had not yet received payment for the expense of creating an app for the coconut business at the time of the interview.

The general manager added that Yello Media and the CIB have been working together to update the website.

The CIB is a "self-funding entity, so it will come from our internal funds," Cameron said in response to a query about how the infrastructure will be paid for. When questioned further regarding government funding, he responded that the group had not gotten any subsidies.

"I should note that the Coconut Industry Board has been self-funding since 1945, and much of the study we conduct is dependent on our local funds. Because we operate as a company and strive to keep, not necessarily our profitability but our relevance in the industry, we furnish the industry with local money," he explained.

"As we move into agro-processing, we must be more stringent and financially responsible in how we manage our resources to grow the industry by utilising cutting-edge methods of connecting with our farmers," added Cameron.

In response to questions about the support he has received from farmers in the coconut industry, the general manager stated that one of the choices he made upon accepting his current position was to hold town hall meetings with farmers to meet the CIB team, which includes researchers, and to solicit "feedback" on the direction the board should take.

Cameron pointed out that farmers in the coconut industry now come from the business sector or are young people who are legacy farmers while adding that farmers are moving away from conventional agriculture.

Additionally, he continued, "They are much more tech-savvy and require that the Coconut Industry Board change in order to support technology and accessibility in the future."

Therefore, he continued, "Farmers are now more sophisticated and want to know from a study standpoint how they benefit, and from the board's standpoint what we are doing for the industry to help them expand their company and move into agro-processing."

According to Cameron, the coconut industry has profited from some younger farmers joining the industry, though he was unable to estimate the number of farmers under the age of 40.

Nevertheless, he claimed that the CIB has contacted the Jamaica 4-H Clubs to work with them in hiring farmers in this age demographic because it has been heartened by the number of young farmers. *(Jamaica Observer)*

INCREASING DEMAND FOR COCONUT SEEDLINGS

Speaking at the course, the Nigerian Minister of Agriculture, Dr Muhammad Abubakar, said the program was one of the federal government's aim to accomplish food security and self-sufficiency in Nigeria.

"In an effort to accomplish food security, self-sufficiency, as well as enhance the livelihood of coconut farmers and processors, the government, through the coconut value chain, chose to give you with the required knowledge and skills to create and manage a profitable plantation," he added.

The minister, who was represented by Chukwuemeka Ukattah, a director in the ministry, said members of staff will be taught on nursery setup, field development, harvesting and processing to satisfy local and worldwide markets standard and demand.

On his part, the executive director of the Nigerian Institute for Oil Palm Research (NIFOR), Dr Celestine Ikuenobe, stated that Nigeria's coconut production was well below the need.

"I am convinced that if the National Coconut Producers Processors and Marketers Association of Nigeria (NACOPPMAN) worked with this agro-forestry based planting model, the coconut value chain would be on a scale that could contribute very significantly to our economy.

"We suddenly had a tremendous demand for coconut seedlings in the last three to four years, but we were caught sleeping since we did not plan for the fact that there was going to be an explosion in the demand for coconut seedlings," he added. *(Daily Trust)*

FARMERS' MEETING ORGANIZED BY COCONUT DEVELOPMENT BOARD IN UDUPI

The Coconut Development Board (CDB) hosted the CDB Foundation Day Celebration and Farmers Meet at the Shesha Krishna Convention Hall in Kundapura in collaboration with the Horticulture Department, Zilla Panchayath, Udupi, and UKCAAS Producer Company Ltd. The program was launched by Shobha Karandlaje, Federal Minister of State for Agriculture.

The meeting was followed by technical workshops, discussions between farmers and scientists about various issues and future developments relating to the cultivation of coconuts, as well as a display of cutting-edge coconut products.

According to a statement released here, India has the third-largest area planted with coconuts and is the most productive and successful country for growing coconuts. In 2021–2022, the coconut sector produced 20,309 million nuts, or more than 31% of global production. Per acre, 9,346 nuts were produced in total. There are 21.73 lakh hectares of coconuts growing over the entire country. The four southern States, comprising Kerala, Karnataka, Tamil Nadu, and Andhra Pradesh, produce almost 90% of the acreage and output.

Karnataka produces the majority of the world's coconuts on its 5.5733 lakh hectares. In the State, 5,897.32 million nuts were produced, yielding 10,581 nuts per hectare. The productivity is much higher than the 9,123 nuts per hectare average for the country. The State contributes about 26.42 percent of the land and 30.64 percent of the production of coconuts in India.

The next largest districts are Hassan (97,999 hectares; 4,759.81 lakh nuts), Mandya, and Tumkur (1,78,748 hectares; 13,123.68 lakh nuts, respectively) (67106 hectares – 6,009.34 lakh nuts). *(The Hindu Business Line)*

A SAVE SOIL CONFERENCE ON COCONUT CULTIVATION IN POLLACHI DRAWS 1,500 FARMERS

A farmer's seminar on developing 15 streams of income from coconut agriculture was held in Pollachi as part of Isha's Save Soil movement. At the meeting held at the Nallamuthu Gounder Mahalingam College, almost 1,500 farmers from all over Tamil Nadu took part. The occasion was attended by Mr. K Shanmugasundaram, a Pollachi MP, Mrs. S Priyanka, a Pollachi sub-collector, and Mr. GGD Gopalakrishnan, the head of the Pollachi Chamber of Commerce.

Mr. Valluvan, a pioneer in natural farming, Mr. Ko Siddhar, a Siddha physician, Mr. Saminathan, an entomologist, Mr. Saravanan Kandasami, a soil expert, Mrs. Josephine Mary (VPS), honey bee farmer, Mrs. Yamuna Devi, a young entrepreneur, Mr. Tamil Maran, Cauvery Calling Field Coordinator and Mr. Dhanapal, Neera manufacturer spoke at the conference and shared many ideas.

Specialists also discussed ways to improve soil fertility in order to enhance coconut production as well as strategies for raising the price of products related to coconuts in order to increase farmer income.

Also, issues like employing neera to make money all year long, preserving coconut trees against white bug infestation, and intercropping coconut with high-value crops like pepper and timber trees were covered. Bee boxes in the coconut grove were also highlighted. Discussions at the conference also included the coconut tree's therapeutic properties, different daily issues faced by coconut growers, and solutions to these issues. *(The Covai Post)*

Statistics

Table 1. WORLD Exports of Coconut Oil, 2017-2023 (MT)

COUNTRY	2017	2018	2019	2020	2021	2022	2023[F]
A. ICC Countries	**1,584,413**	**1,805,748**	**2,046,921**	**1,687,810**	**1,730,114**	**2,110,218**	**1,924,847**
F.S. Micronesia	87	57	-	-	-	-	-
Fiji	1,957	3,261	2,487	2,533	1,460	1,211	2,152
India	11,726	6,831	7,828	11,096	14,445	28,321	13,374
Indonesia	510,441	675,138	610,812	577,645	611,452	685,878	665,000
Jamaica	6	5	6	9	-	1	5
Kenya	55	36	44	55	655	215	177
Kiribati	1,359	3,493	3,561	2,517	1,829	1,528	2,381
Malaysia	102,735	121,914	223,078	203,362	186,608	134,871	148,000
Marshall Islands	1,524	2,229	1,085	1,115	402	709	1,177
Papua New Guinea	15,740	12,566	20,975	17,732	10,099	16,269	37,000
Philippines	912,631	951,320	1,146,642	842,533	881,085	1,219,792	1,020,000
Samoa	116	141	424	8	116	183	165
Solomon Islands	5,515	5,432	4,561	5,272	5,225	5,019	5,171
Sri Lanka	6,310	4,606	4,056	5,180	3,825	4,712	14,000
Tonga	-	-	-	-	-	-	-
Thailand	1,331	1,266	1,337	1,745	1,686	1,062	1,405
Vanuatu	2,543	3,669	3,498	1,367	711	428	2,036
Vietnam	10,337	13,784	16,527	15,641	10,516	10,019	12,804
B. Other Countries	**369,896**	**317,883**	**317,407**	**341,233**	**330,307**	**202,794**	**143,153**
TOTAL	**1,954,309**	**2,123,631**	**2,364,328**	**2,029,043**	**2,060,421**	**2,313,012**	**2,068,000**

F: Forcasted figures; Source: ICC, ITC and Oil World

Table 2. Prices of Coconut Products and Selected Vegetable Oils, July 2022 – June 2023 (US$/MT)

Products	2022							2023				
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Copra	966	797	685	662	605	652	641	621	630	627	625	626
Coconut Oil	1,688	1,517	1,364	1,261	1,094	1,167	1,155	1,071	1,107	1,111	1,069	1,031
Copra Meal[2]	238	248	243	243	282	301	302	300	299	300	288	277
Desicc. Coconut[2]	2,408	2,307	2,021	1,984	1,984	1,957	1,947	1,874	1,874	1,874	1,874	1,828
Mattress Fiber[1]	64	62	62	60	49	39	48	42	36	45	51	49
Shell Charcoal[2]	385	364	365	371	364	373	377	370	368	357	350	345
Palm Kernel Oil	1,555	1,301	1,173	1,249	1,039	1,062	1,067	1,060	1,037	1,052	1,017	993
Palm Oil	1,501	1,203	1,095	1,048	1,043	946	940	1024	997	1070	1,005	934
Soybean Oil	1,752	1,752	1,533	1,599	1,548	1,576	1,652	1,409	1,752	1,533	1,030	988

1: Sri Lanka (FOB); 2: Philippines (FOB); r: revised; Source: ICC and Oil World

Table 3. World Oil Balance 2021-2023 (million tons)

Oil/Year	Oct-Sept 22/23F	Oct-Sept 21/22	Oct-Sept 20/21
Palm Oil			
Opening Stocks	15.06	12.37	12.74
Production	80.43	77.35	76.01
Imports	51.65	47.33	51.65
Exports	51.89	47.92	51.53
Disappear	79.63	74.08	76.50
Ending Stocks	15.63	15.06	12.37
Soybean Oil			
Opening Stocks	6.43	6.71	6.38
Production	59.27	59.90	59.44
Imports	11.96	13.00	13.11
Exports	11.85	13.06	13.29
Disappear	59.55	60.12	58.94
Ending Stocks	6.27	6.43	6.71
Groundnut Oil			
Opening Stocks	0.28	0.30	0.23
Production	4.52	4.73	4.28
Imports	0.42	0.30	0.48
Exports	0.41	0.32	0.46
Disappear	4.58	4.74	4.22
Ending Stocks	0.23	0.28	0.30
Sunflower Oil			
Opening Stocks	3.61	2.45	2.88
Production	21.01	20.57	18.93
Imports	12.82	11.24	11.38
Exports	12.96	11.39	11.32
Disappear	20.78	19.25	19.41
Ending Stocks	3.69	3.61	2.45
Rapeseed Oil			
Opening Stocks	2.98	3.54	3.14
Production	29.31	26.01	27.17
Imports	6.14	5.26	6.56
Exports	6.21	5.22	6.45
Disappear	28.84	26.62	26.88
Ending Stocks	3.38	2.98	3.54
Cotton Oil			
Opening Stocks	0.27	0.30	0.30
Production	4.37	4.35	4.44
Imports	0.13	0.15	0.13
Exports	0.13	0.15	0.14
Disappear	4.34	4.37	4.44
Ending Stocks	0.31	0.27	0.30

Oil/Year	Oct-Sept 22/23F	Oct-Sept 21/22	Oct-Sept 20/21
Palm Kernel Oil			
Opening Stocks	1.35	1.25	1.37
Production	8.45	8.13	7.94
Imports	3.32	3.01	3.34
Exports	3.29	3.10	3.38
Disappear	8.38	7.94	8.01
Ending Stocks	1.44	1.35	1.25
Coconut Oil			
Opening Stocks	0.44	0.36	0.47
Production	2.94	3.15	2.65
Imports	2.04	2.35	1.92
Exports	2.07	2.30	1.83
Disappear	2.99	3.13	2.83
Ending Stocks	0.36	0.44	0.36

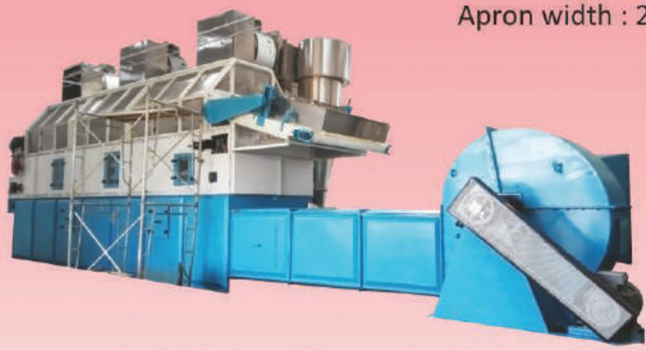
Source: ICC and Oil World F: forecast figures

DESICCATED COCONUT PROCESSING MACHINERY

"Over 100 machines in operation worldwide"

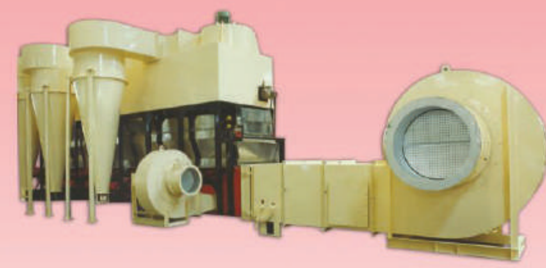
BAND DRYER (APRON/CONTINUOS TRAY DRYER)

for Desiccated Coconut Granules, Chips & Toasted D/C
Output Capacity : 1000 to 2500 Kgs/hr.
Two Stage and Three Stage Dryers.
Apron width : 2640mm and 3250mm



COMBINATION DRYER

for Desiccated Coconut Granules, Chips, Toasted D/C & Parings.
Output Capacity : 300 to 1000 Kgs/hr.



VIBRATORY FLUID BED DRYER

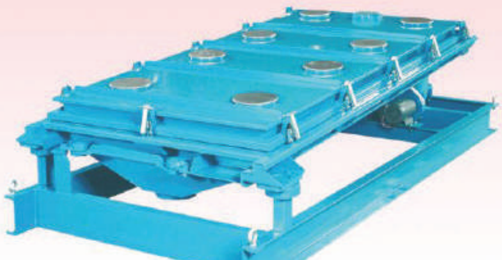
for Desiccated Coconut Granules & Parings.
Output Capacity : 300 to 1000 Kgs/hr.

GRINDER

Output Capacity:
1000Kgs/hr.

BLANCHER

Output Capacity :
1000 to 4000 Kgs/hr.



NOVATEX SCREENER/GRADER

Output Capacity :
1000 to 1500 Kgs/hr.

DESHELLING MAHINE
Output Capacity :
250 to 300 nuts/hr.

DEHUSKING MACHINE
Output Capacity :
1200 nuts/hr.

OIL EXPELLER

RADIATOR
Extruded Fins or Plate Fins Type

STAINLESS STEEL PERFORATED APRON TRAYS
Width: 2640mm & 3250mm

STAINLESS STEEL CHAIN

GEM

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