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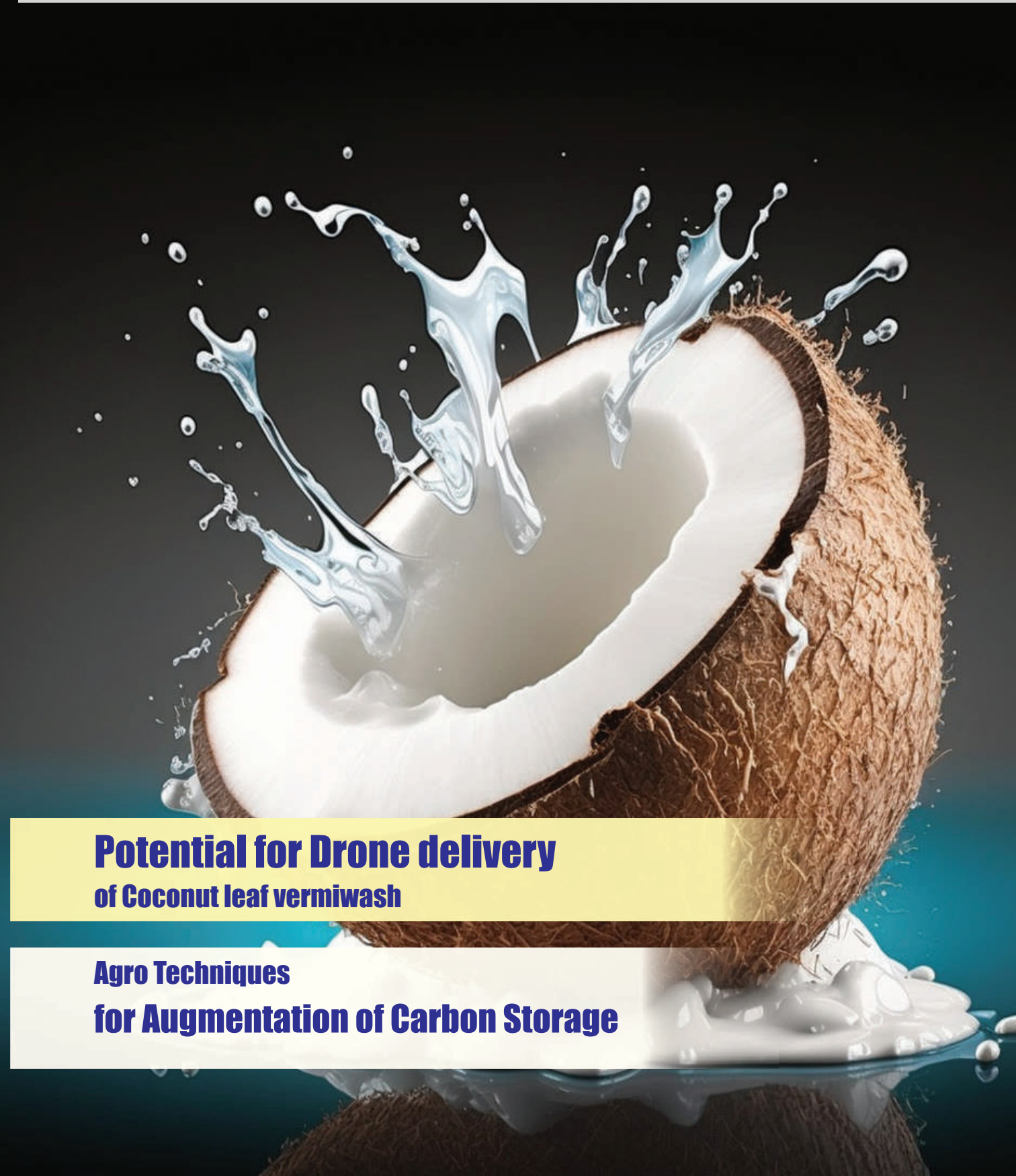

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of Coconut leaf vermiwash

Agro Techniques
for Augmentation of Carbon Storage

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Coconut Development Board

The Coconut Development Board is a statutory body established by the Government of India for the integrated development of coconut cultivation and industry in the country. The Board which came into existence on 12th January, 1981, functions under the administrative control of the Ministry of Agriculture and Farmers Welfare, Government of India, with its headquarters at Kochi in Kerala State and Regional Offices at Bangalore, Chennai, Guwahati and Patna. There are five State Centres situated in the states of Orissa, West Bengal, Maharashtra and Andhra Pradesh and in the Union Territory of Andaman & Nicobar Islands. DSP Farms are located at Neriyamangalam (Kerala), Vegiwada (Andhra Pradesh), Kondagaon (Chhattisgarh), Madehpura (Bihar), Abhayapuri (Assam), Pitapalli (Orissa), Mandya (Karnataka), Palghar (Maharashtra), Dhali (Tamil Nadu), South Hichachara (Tripura) and Fulia (West Bengal) besides a Market Development cum Information Centre at Delhi. The Board has set up a Technology Development Centre at Vazhakulam near Aluva in Kerala.

Functions

❒ Adopting measures for the development of coconut industry. ❒ Recommending measures for improving marketing of coconut and its products. ❒ Imparting technical advice to those engaged in coconut cultivation and industry. ❒ Providing financial and other assistance for expansion of area under coconut. ❒ Encouraging adoption of modern technologies for processing of coconut and its products. ❒ Adopting measures to get incentive prices for coconut and its products. ❒ Recommending measures for regulating imports and exports of coconut and its products. ❒ Fixing grades, specifications and standards for coconut and its products. ❒ Financing suitable schemes to increase the production of coconut and to improve the quality and yield of coconut.

❒ Assisting, encouraging, promoting and financing agricultural, technological, industrial or economic research on coconut and its products. ❒ Financing suitable schemes where coconut is grown on large scale so as to increase the production of coconut and to improve its quality and yield and for this purpose evolving schemes for award of prizes or grant of incentives to growers of coconut and the manufacturers of its products and for providing marketing facilities for coconut and its products. ❒ Collecting statistics on production, processing and marketing of coconut and its products and publishing them. ❒ Undertaking publicity activities and publishing books and periodicals on coconut and its products.

The development programmes implemented by the Board under the project Integrated Development of Coconut Industry in India are- production and distribution of planting material, expansion of area under coconut, integrated farming for productivity improvement, technology demonstration, market promotion and Information and Information Technology. Under the Technology Mission on Coconut, the programmes implemented by the Board are development, demonstration and adoption of technologies for management of insect pest and disease affected coconut gardens, development and adoption of technologies for processing and product diversification and market research and promotion.

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Dear Friends,

The financial year is coming to an end and the successful culmination of the International Conference of Trade and Marketing of coconut products organized by Coconut Development Board in collaboration with the International Coconut Community during 27-28 February in Hyderabad instilled enthusiasm into the coconut sector. The talk by experts in various field from major coconut growing countries presented a picture of the current status of trade and marketing of coconut and its products in the global scenario. It was soothing to realize that our problems in the coconut trade were not ours alone, but constraints faced by all coconut growing countries which included the weakening of prices of coconut, copra and coconut oil, the issues created by the pandemic, supply chain disruptions, increased freight costs, logistic issues, increased stock of copra and coconut oil etc.

The open and active interactions between the experts and the participants threw light on the way forward. The need to stand together as a community was felt much stronger during the discussions especially due to the weakening of prices globally. The need to identify new markets in growing economies was felt by the participants taking into account the slowdown in economy in the advanced countries of Europe and USA who were major consumers of coconut products.

The need for sustainable sourcing became a discussion point and it was a positive act in the progression of the coconut sector with the industry thinking of ways and means to ensure sustainable coconut sourcing. The need for introducing sustainability standards in productivity, conservation, livelihood security and socioeconomic and ecological sustainability were stressed which was on par with the need for adaptation and climate resilience.

It is very much important for the sector to capitalize on the goodness of coconut and promote it as an ideal plant based food to the new generation. Coconut is truly vegan, gluten free, dairy free and with zero waste, thus ideally suited to the changing and evolving lifestyle post pandemic where the consumer had turned conscious of not only his health but his environment too. The need of the hour is increased application of technology and ensuring transparency, quality, traceability and reliability. The general feel was that the sector will rebound soon with better prices as the demand for coconut products is expected to continue as they are necessary materials for many consumer goods.

Let us hope that the new financial year will be a sunshine year for the coconut sector.

Editor

Agro techniques for augmentation of carbon storage through crop residue recycling in coconut-based cropping system

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Healthy soil is the key towards sustainable agriculture. Healthy soil encompasses the ability of soil to sustain the plant growth, ensuring the soil fertility and its productivity, sustain the growth of soil microbes, resilient to climate change and associated vagaries and ultimately the balanced food production for feeding the millions. Soil organic carbon plays a key role on maintenance of the healthy state of the soil. On volume basis, the percentage composition of an ideal cultivable soil is 50 per cent pore space and 50 per cent solids. Of the 50 per cent solids, 45 per cent constitutes mineral matter and 5 per cent forms the organic matter, which in turn makes the soil healthy. The physical, chemical and biological properties of the soil are solely dependent on the soil organic matter. Soil organic carbon is a measure of the carbon contained within the soil organic matter.

Basin managment

The physical properties like soil aggregation, nutrient holding capacity and soil structure are improved by the organic matter content of the soil. Through the process of microbial mediated mineralization, soil organic matter becomes the source of nutrients and increase the microbial activity. In short organic matter enables better plant establishment. Apart from the focus on enriching soil organic carbon content, its maintenance or conservation is also equally important from the point of view of the emission as carbon dioxide, a major contributor towards the greenhouse gas effect. Carbon neutral farming is gaining momentum all across the world. Carbon neutrality is a state of net zero carbon dioxide emissions, which shall be achieved by balancing emission with its removal by assimilation/ sequestration or by eliminating emissions through the processes associated with transport, energy production, agriculture and industry. In agriculture systems, the state of neutrality can be achieved when the emitted carbon dioxide is absorbed in the soil itself.

The recently concluded COP27 summit held at Egypt, has underlined India's position of reaching

net zero by 2070. India's view of ensuring low carbon development is based on expansion of renewable energy sources as well as optimum and sustainable use of fossil fuel resources.

Agricultural related emissions of carbon dioxide account for around 24% of the global greenhouse gas emissions. The impact can be reduced by the adoption of conservation agriculture, cover cropping, incorporation of crop residues, agroforestry and increasing the cropping intensity. The practice of stubble burning should be avoided totally. This article elaborates the various agro techniques for augmentation of soil carbon storage in coconut-based cropping system.

Coconut, the tree crop having an average life span of 80 years, is the Kalpa Vriksha, with all the palm parts beneficial to mankind. On the basis of residue recycling potential, the entire tree can be categorised into removable, recyclable and reserve biomass. The removable biomass constitutes the harvestable nuts, whereas the recyclable biomass includes the leaves, husk, fibre, rachis and coconut shell, which can be recycled back through *in situ* palm residue recycling. It also has the capacity to be composted and be incorporated into the soil. The reserve biomass is the stem which will be incorporated only when the tree is felled. Studies conducted at ICAR-CPCRI have shown that 78 per cent of the total biomass is the reserve biomass, 20 per cent constitute the recyclable biomass and 2 per cent forms the removable biomass. Hence there is ample scope for turning in the palm residues into the soil. This practice can incorporate the organic carbon contained in the above ground biomass and thereby enriching the soil organic matter status. On an average, 1 ha coconut plantation produces approximately 14-20 tonnes of biomass which if incorporated in the soil may enrich the organic carbon status of soil. Through the destructive sampling and analysis studies done at ICAR-NIASM, it has been found that the mean carbon content in coconut biomass was 39.84%, with a carbon stock of 7.92Mg C/ha. The carbon sequestration rate was found to be 8.07 Mg C/ha . The net carbon dioxide mitigation potential in coconut orchard was 68.59 Mg CO_2 eq/ha (Chavan, 2022).

In the studies conducted with the assistance of Kerala State Planning Board, (2019), it was observed that the organic matter enrichment of the soil was facilitated by the addition of all the palm residues in sandy and laterite soils of Kerala. The palm residues such as leaves, husk and coir pith have the scope of being composted and becoming enriched in mineral composition and properties.

Coconut leaf vermicomposting

It has been estimated that approximately 6-7 tonnes of fallen leaves are generated from a hectare of coconut garden. These leaves, owing to the content of lignin and polyphenols, will not be properly decomposed naturally, but the decomposition can be accelerated using the earthworm *Eudrilus sp.*

In cement tanks of 1 meter depth, coconut leaves which are withered for 2-3 months are cut and placed, over which a layer of cow dung slurry is applied. For 1 tonne waste, 100 kg cow dung slurry is required. This pre decomposition is continued for 2-3 weeks. After which 1000 worms per tonne of the substrate are introduced. The substrate will be converted to compost within a period of 60-75 days. Vermicompost contains 1.8 to 2.1 % N, 0.21 to 0.3 % P and 0.16 to 0.4 % K and organic carbon content of 18-20% (Gopal et al.2017).

Coconut husk burial

Coconut husk burial is an effective technology for the retention of soil moisture, improving the water holding capacity of the soil, enhancing the available potassium status of the soil, improving the nutrient holding

capacity and reducing the leaching loss of nutrients for the soil particularly that of the sandy soil. The raw coconut husk is composed of 30% fiber and 70% pith with high lignin and phenolic content. Apart from the conservation of soil moisture and the enhancement of moisture holding capacity, husk is a potential nutrient reserve particularly that of potassium. It has been reported that on an average 100,000 husks contain potash equivalent to 1 tonne of muriate of potash, which is also made available to the palm (Subramanian et al.2009).

Coir pith composting

Raw coir pith is the by product of coir industry, which in turn is the mesocarp fibre from coconut husk. Application of raw coir pith is not advisable owing to high amounts of lingo cellulose which hampers the growth of microbes as well as deleterious effects on root proliferation and development. Hence the composted coir pith is necessary for supplying the requisite quantity of nutrients and maintaining the soil health. It is the preferred soil conditioner and organic manure under the organic horticultural systems. Composted coir pith resembles the peat and has excellent moisture retention capacity. Thomas et al (2013) The bio conversion of raw coir pith to compost is facilitated by the addition of poultry manure in 45 days. During this process the bioconversion of raw coir pith to compost resulted in the reduction of C:N ratio from 100:1 to 21.42:1.

Potential of native weed species in coconut garden

Weed management often presents a cumbersome task to the coconut farmers especially in the rainy season. But these weeds have the excellent potential to serve as mulch in the coconut basin. They can also be composted to provide nutrient rich compost which can be incorporated in the soil to provide the organic matter. The monocotyledonous weed species such as *Setaria sp., Cyprus rotundus, Cenchrus ciliaris, Commelina benghalensis, Brachiaria mutica* and that of dicotyledonous weeds such as *ipomeapestigridis, Agropyran repens* were collected and dried in the shade. These withered vegetation were fed into cement tanks of 1 m depth and 1m diameter, @20 kg per pit and 5kg dung 25 earthworms. Moisture was ensured by sprinkling water periodically. The well decomposed and pulverized compost was ready after three months. These compost samples were analysed for the available nutrients and were found to be rich nutrient sources such as N (0.5%), P(0.121%), K(0.71%), Ca (0.780%), Mg(0.19%), Cu(59.87 mg/kg)and Zn (22.5 mg/kg), Mn (77.38 mg/kg). The value addition from the common upland weeds in coconut gardens offers a novel approach for crop residue recycling in coconut based cropping system.

Growing green manure crops in the coconut basin is an effective strategy to improve the soil organic matter content. It could also prevent soil erosion; improve the soil structure and the water holding capacity of the soil

Basin management with leguminous crops for enriching soil organic matter

Growing green manure crops in the coconut basin is an effective strategy to improve the soil organic matter content. It could also prevent soil erosion; improve the soil structure and the water holding capacity of the soil. It also enriches the soil fertility. Leguminous crops fixes atmospheric nitrogen in the root nodules. Crops

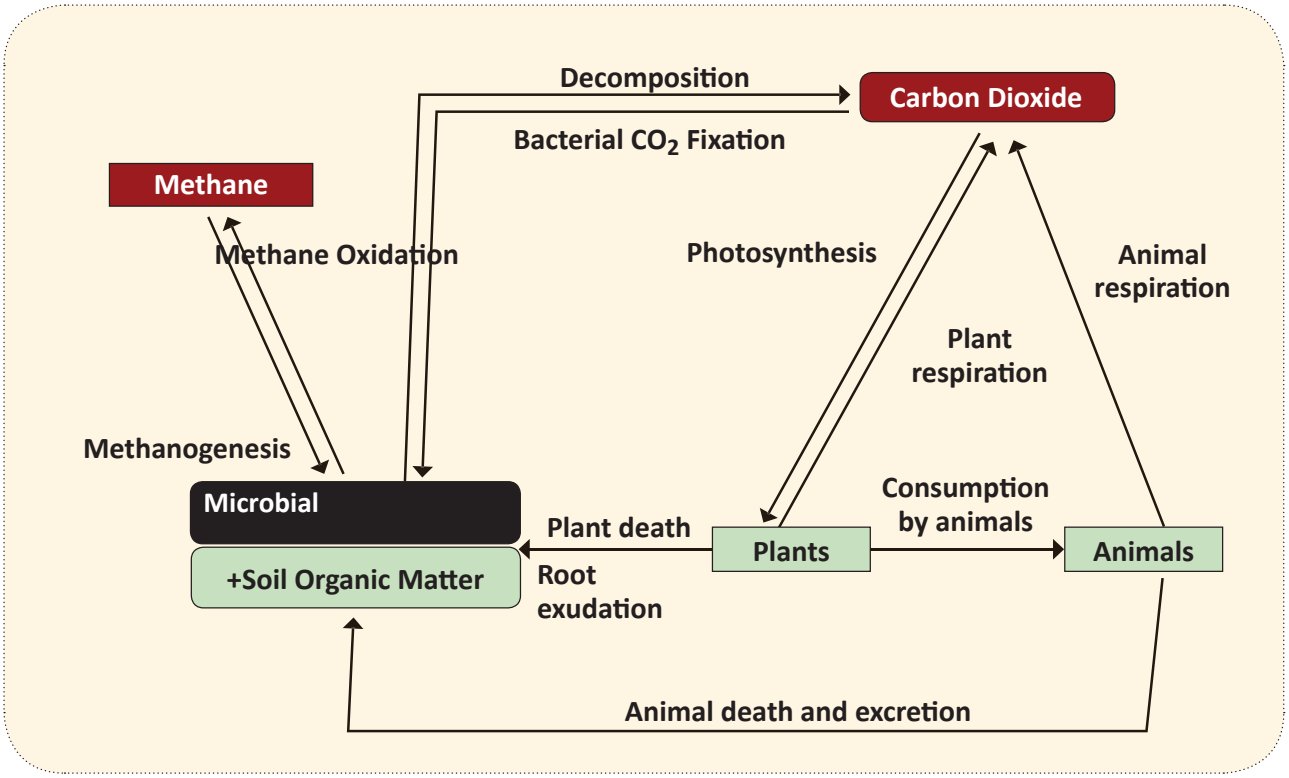

Figure 1. Microbial mediated terrestrial carbon cycle (Gouglias et al. 2014)

such as cowpea and sunhemp can be sown in the basin during the monsoon period from June to August and the biomass can be later incorporated in the coconut basins. 100g cowpea seeds can be sown in the basin during the time of application of first split (1/3rd of the total dose) fertiliser application. At the time of the 50 per cent flowering of the crop, it can be uprooted and incorporated in the basins. It has been estimated that the incorporation can contribute to approximately 25kg biomass per basin. The average nutrient content in cowpea biomass is 2.87%N, 0.22% P and 2.14%K. Incorporation of cowpea can contribute 145g N, 11g phosphorus and 108g potassium per basin. Hence it can substitute 29% nitrogen requirement, and 9 per cent requirement of phosphorus and potassium. The nutrient content of sun hemp biomass is 2.94%N, 0.18% phosphorus and 1.43% potassium and the availability of NPK per palm basin through the incorporation of sun hemp is 142g nitrogen, 9g phosphorus and 37g potassium, through which 29% substitution of nitrogen, 8% that of phosphorus requirement and 3% of potassium requirement can be substituted. Hence it can be seen that addition of green manure corps can contribute nutrients to soil and compensate for nutrient imbalances and additional requirements.

Glyricedia is a leguminous tree crop which can be grown in the interspaces of coconut garden particularly in the coastal sandy soils. Planting of three rows of glyricidia in between two rows of coconut with three pruning per year resulted in higher biomass yield of 7970 kg/ha. Application of glyricidia pruning from the interspace of one hectare of coconut garden supplied to the coconut palms 88% nitrogen requirement, 27% phosphorus and 13% potassium requirement of coconut palms. It can also enrich the micronutrients such as copper, zinc and boron. However, it may be ensured that wherever successful intercropping is possible, crops may be given preference considering the net returns.

Microbe mediated carbon sequestration

Soil microbial community has a predominant role in carbon cycling and the composition of this community maintains the soil ecosystem services, regulates the turnover and delivery of nutrients and the rate of decomposition of organic matter. Decomposition of organic matter and soil respiration are crucial for

sequestering carbon in the soil and the emission of carbon dioxide. The terrestrial carbon cycle is maintained by the balance between photosynthesis and respiration. Thomas et al. (2010) found that in the high density multi species cropping systems, the microbial biomass carbon (MBC) was significantly higher in the root zone of coconut as compared to that of other component crops. Studies indicated that medium fertiliser levels supported higher microbial biomass and the ratio of microbial biomass to total carbon was also higher.

Incorporation of intercrop residues

It has been estimated that intercrops such as elephant foot yam, ginger, turmeric, ragi and sesame has excellent carbon recycling potential when the residues of these crops are incorporated after their harvest. Addition of crop residues over the years resulted in improvement in organic carbon status. Mago et al. (2021) found that banana leaf biomass amended with cowdung is a good feed substrate for earthworms and 20–40% proportion of Banana crop biomass in waste mixture showed promising results of waste mineralization and earthworm growth. Hussain et al. (2008) found that the available biomass from 1 ha Arecanut based HDMSCS fertilised with 2/3rd fertiliser recommendation generated 6.28t/ha biomass from arecanut, 0.93t/ha from pepper, 2.08t/ha from banana, 0.58t/ha from clove and 0.71t/ha from citrus and it could generate compost to the tune of 8.4t/ha.

Liming

Liming is an absolute pre requisite for the correction of soil reaction in acid soils. It is recommended to apply 1kg lime or dolomite two weeks prior to the fertiliser application. In the field experiments conducted at the farmers' fields in AEU-3 (Onattukara sandy soil) and AEU-9 (South Central laterite soil), it has been found that application of sufficient quantity of liming materials enriched the exchangeable calcium status of the soil.

Ginger intercroping

This resulted in the proliferation of earth worms in the soil, accelerating the organic matter turn over. This was evidenced by the profusion of the earth worm castings in the study sites.

Balanced application of fertilisers

Soil test-based application of nutrients including the major, secondary and micronutrients will enhance their use efficiency and prevent the leaching loss. This will result in the reduced dependence to fossil fuels by fertiliser industry and thereby reduce the emission potential. Wherever possible, straight fertiliser should be applied to prevent the possible nutrient imbalance in the soil. On the basis of soil test data, if the content of available phosphorus is greater than 20 ppm, phosphatic fertiliser application can be skipped until the levels of available phosphorus are reduced. Regular assessment of available nutrients in the soil through scientific soil testing and integrated nutrient management reduce the dependency on chemical fertilisers and enable to explore alternate strategies to supply the needed nutrients for the particular crop.

Way forward

- Reducing emissions and increasing the soil carbon storage has become the national mission towards sustainability.
- Coconut being the perennial plantation crop and having a global distribution in 93 countries globally has the vast potential to favour a climate resilient agriculture, along with enhancement of carbon storage in the coconut-based cropping system.
- Economic viability and environmental sustainability should be equally targeted for sustainable production
- Various agro techniques should be selected, tailoring to the prevailing agro climatic situations of the locality and also enhancing the soil sustainability and overall productivity of the crop.
- Selection of intercrops for crop diversification, cropping intensity, considering agro-climatic and socio economic situations
- Balanced nutrient application, *in situ* palm residue incorporation, composting are the potential strategies to facilitate maximum carbon storage and minimising emission from the coconut-based cropping system.

Potential for drone delivery of coconut leaf vermiwash (Kalpa Vermiwash) for boosting organic agriculture

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Foliar fertilizer application by a drone

Drone technology in agriculture

Drone technology, i.e. unmanned aerial vehicle, is increasingly getting integrated in Indian agriculture for survey of crop coverage, disease and pest detection, assessing soil conditions; identification of nutrient deficiency in crops, application of liquid fertilizers and plant protection chemicals, yield data collection and many other aspects. Utilization of drone technology could help farmers improve their crop yields through efficient use of resources and labour.

Drone for spraying agro-chemicals

Spraying of fertilizers by drones has become a popular agronomic intervention. It is possible to apply optimum amount of liquid fertilizer at right time in short span for large areas. The biggest advantage is precision application compared with traditional methods. This greatly prevents loss of nutrients while reducing the farmers' expenditure.

For spraying purpose, drones must i) be able to cover entire field in minimum numbers of flights, ii) have enough payload capacity to carry sufficient amounts of the liquid fertilizer to cover the area, iii) a high-pressure spraying system and if possible iv) wide-angle camera to capture high-resolution images and videos, and v) GPS navigation system for precise application of the fertilizer. Moreover, to avoid wastage of the liquid fertilizer as drift loss, having information on weather factors such as wind speed and direction will be helpful to command the drone for precision application. In order to use drone efficiently, models with integrated

variable spray system driven by artificial neural network have been developed. These models have software embedded in the drone that regulates the flow rate, and accordingly the deposition rate deposition on target surface. To reduce falling of sprays on non-target areas, modular anti-drift nozzles can be used. Further, the mechanical, electric and electronic components could be altered as per requirements.

Spraying drones are used for application of different agro-chemicals on crops. One among them is foliar fertilization. It is particularly useful if the soil conditions do not allow efficient supply of nutrients due to inherent soil factors, inability of crops to absorb nutrients due to poor rooting or stage of crop when quick uptake of nutrient is required that can be facilitated by foliar absorption etc.

Organic agriculture in India

With Organic Farming being one of the National Priorities in agriculture, farmers will require multiple approaches to adopt this farming system. As per APEDA, the area under organic certification (registered under National Programme on Organic Farming) in India during 2021-22 is 9119865.91 ha that includes close to 50% as cultivable area and rest from wild harvest collection. States having highest area under organic farming are Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Odisha, Karnataka, Uttarakhand, Sikkim, Chhattisgarh, Uttar Pradesh and Jharkhand. The production of organically certified outputs was at 3430735.65 MT during 2021-22 that included several food and fibre produce. Through export of 460320.40 MT of organic products, India could earn Rs. 5249.32 crores. (https://apeda.gov.in/apedawebsite/organic/organic_products.htm#:~:text=As%20on%2031st%20March%202022,ha%20for%20wild%20harvest%20collection)

Status of organic manure production

Organic agriculture is driven by the theme of promoting soil health in ecologically safe manner. Use of chemically synthesized fertilizers and pesticides is avoided as far as possible. Application of fertilizers in fields such as farm yard manure, composts/vermicomposts, de-oiled cake, plant-based pesticides, seaweed fertilizers and bioinoculants form the main inputs in organic farming. These are soil-based interventions. The quantum of organic manure and bioinoculants produced in India during 2020-21, as per NCOF (https://ncof.dacnet.nic.in/StatusOrganicFarming), was around 42940832 MT. In this, the liquid biofertilizer was to the tune of 42239 KL. The innovation of drone technology in agriculture can be now harnessed for aerial application of organic fertilizers in liquid form.

Coconut leaf vermiwash: an earthworm-worked liquid organic fertilizer

ICAR-CPCRI has developed a technology of producing liquid organic fertilizer from coconut leaf vermicomposting technology. The Coconut leaf vermiwash (CLV), branded Kalpa Vermiwash, is a clear-

Coconut leaf vermiwash (Kalpa Vermiwash) produced in plastic barrel or mud pot

brown colour liquid extracted from barrels filled with pre-decomposed coconut leaf mixed with cow dung and mature coconut leaf vermicompost in fixed ratio which is being actively decomposed by earthworms. CLV is alkaline in property and contains all necessary plant nutrients including plant growth promoting hormones and humic acid. It also contains good population of plant-beneficial microbiota, particularly, fluorescent pseudomonads. The liquid is diluted with water and applied as soil or foliar spray. `

Studies in Institute and farmers fields have clearly shown that application of CLV promotes yield of tomatoes, okra, green leafy vegetables and maize. It also promotes microbial communities that improve soil health including Trichoderma spp. and enzyme activities in soil that aid in improving soil health and fertility. Farmers who adopted this technology have noted that application of CLV promoted luxurious growth of fine roots and hairs in green leafy vegetable crops and improved the keeping quality of the harvested leafy vegetable products.

Demonstration trials in farmers' plots with manual spraying appropriately diluted CLV on foliage of amaranthus and cowpea plants in farmers had shown to promote the growth of the vegetable crop. In addition,

Amaranthus with profuse production of fine root hairs in the vermiwash treated (manually) plots at farmers' field in Kasaragod

the vermiwash also promoted epiphytic microbial population and activity that could increase the plant health through enhanced absorption of nutrients and microbial metabolites. Further, since CLV is an organic fertilizer made without the use of any synthetic chemicals, it will not contaminate soils or water bodies or cause harm to any organisms or living beings.

Coconut leaf vermiwash as drone spray

Coconut leaf vermiwash is an earthworm-processed organic liquid fertilizer produced from vermicomposting unit. It contains a wide range of essential nutrients, including nitrogen, phosphorus, potassium, magnesium, zinc, iron as well as plant growth promoting hormones and humic acid. These nutrients are essential for plant growth and development which can be applied as foliar spray to supplement nutrient requirements of plants. By providing essential nutrients to plants, foliar sprays can help them to grow faster, stronger and healthier and become an important component in boosting organic agriculture.

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Biological Control of Invasive Whiteflies in Coconut: Challenges and the Way Forward

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Coconut, *Cocos nucifera L.* (Arecaceae) is an important plantation crop grown mainly in the tropical and subtropical regions of the world, and millions of people depend on this crop directly or indirectly for their livelihood. India is one of the leaders in coconut farming and the third largest coconut producing country in the world. Coconut is a crop of small and marginal farmers since 98% of about five million coconut holdings in the country are less than two hectares. In the west coast of India, the palm is an essential component in the homestead system of farming.

Coconut is grown in a large area of more than 21.73 lakh hectares in more than 15 states and union territories in India with an annual production of 21,309 million nuts with productivity of 9346 nuts/ha. Among all the coconut producing states, Tamil Nadu, Kerala, Karnataka and Andhra Pradesh are the leading coconut producing states which account for more than 90% of the total coconut produced in the country. Coconut production and productivity was 3281.7 million nuts and 5238 nuts/ha during 1950-51 to 20736.12 million nuts and 9430 nuts/ha during 2020-21. India has been exporting coconut oil to Malaysia, Indonesia and Sri Lanka and dry coconut in large quantities to the U.S and European countries.

The coconut palm is attacked by several insect pests all around the year and more than 900 species of pest are associated with cultivated and wild coconut. Coconut Eriophid mite, *Aceria guerreronis Keifer* (Eriophyidae: Acari), rhinoceros beetle, *Oryctes rhinoceros L* (Coleoptera: Scarabaieidae), red palm weevil, *Rhynchophorus ferrugineus Olivier* (Coleoptera: Curculionidae), black headed caterpillar, *Opisina arenosella Walker* (Lepidoptera: Oecophoridae) and white-grub, *Leucopholis coneophora Burmeister* (Coleoptera: Scarabaieidae) are considered as the major pests of coconut. While the two whiteflies viz., areca nut whitefly, *Aleurocanthus arecae* David and Manjunatha (Hemiptera: Aleyrodidae) and spiraling whitefly, *Aleurodicus dispersus* recorded on coconut in India are considered as minor pests (Josephrajkumar et al., 2012).

Between 2016-2019, the following four exotic whiteflies viz., rugose spiraling whitefly, *Aleurodicus rugioperculatus Martin* during 2016; Bondar's nesting whitefly, *Paraleyrodes bondari Peracchi*, nesting whitefly, P. minei Iaccarino during 2018 and palm infesting whitefly, *Aleurotrachelus atratus Hempel* (Sundararaj et al., 2021) invaded to coconut ecosystem (Fig.1). It was reported that *Aleurodicus rugioperculatus* co-exist with *Aleurotrachalus atratus*, P. bondari, A. dispersus and P. minei on coconut. Infestations of A. atratus and *A. rugioperculatus* along with *Aleurocanthus arecae*, a native whitefly species were commonly observed on coconut. These invasive species are native to the Neotropical region mostly from Central America and the Caribbean. Invasion of these exotic species leads to abrupt outbreaks in several locations due to favourable weather condition and availability of host plants. The most insidious spread are those mediated by humans through infested seedlings.

Invasive species pose constant threat to agriculture and a strategic science based approach is needed to promote environmentally sustainable plant health management practices to reduce excessive reliance on chemical pesticides. Biological control through parasitoids, predators and entomopathogens constitutes a significant component in holistic management of insect pests.

Fig. 1. Invasive whiteflies infesting coconut

Moreover, Agricultural policies in India have emphasized adopting biological control as a component of Integrated Pest Management (IPM) to minimize the indiscriminate and injudicious use of chemical pesticides. Implementation of biological control at the national level not only scaled down the dependence on pesticide usage but also reduced pest-induced losses in the country. In addition to catering to domestic requirements, the research and development on biological control in India have extended global support by providing the natural enemies of Indian origin to be established in other countries for crop pest suppression, thereby becoming a global player in providing clean and green pest management strategies.

The recent advances in artificial intelliance (AI), the internet of things (IOT), Drones and Genome Editing technologies have opened new vistas leading to need based temporal and spatial specific plant protection interventions to ensure minimized usage of synthetic pesticides. Further such approaches fit into SDG and Global one-health goals. Biological control using parasitoids, predators and entomopathogens are the most feasible, efficient, eco-friendly method and alternative to the use of insecticides. Success of any biological control programme depends on their effective and timely application in a systematic way. This can be made possible by creating awareness to farmers, early detection of the pest, frequent monitoring, large scale approach and repeated release of parasitoids.

Biological control of invasive whiteflies

Alarmed by the invasion of these invasive species unknown to them, farmers resorted to spraying of chemical pesticides to control. But the efforts were in vain as the chemicals turned out to be a temporary fix and moreover, other ill effects like environmental pollution, killing of natural enemies, pollinators and other non-target organisms and health risks to the people involved in spraying operations made the insecticide application a risky business apart from being uneconomical.

Biological control based approach for the management of the invasive whiteflies is an effective and sustainable. Explorative surveys were carried out for the biological control of these invasive pests through naturally occurring insect predators and parasitoids.

Biological control based approach for the management of these invasive whiteflies is an effective and sustainable solution. Explorative surveys were carried out for the biological control of these invasive pests through naturally occurring insect predators and parasitoids which are economically feasible, ecologically compatible and environmentally benign.

Two parasitoids, *Encarsia guadeloupae Viggiani* and *E. dispersa Polaszek* (Hymenoptera: Aphelinidae) on *A. rugioperculatus* and *A. dispersus* and a parasitoid, *Encarsia cubensis* on *A. atratus* (Selvaraj et al., 2017; Selvaraj et al., 2023) were recorded (Fig.2); Predators such as *Apertochrysa* (=Pseudomallada) astur (Neuroptera: Chrysopidae), J*auravia pallidula, Cheilomenes sexmaculata* (Coleoptera: Coccinellidae) and *Cybocephalus indicus* (Coleoptera: Nitidulidae) were also observed to be feeding on these invasive whitefly species in coconut (Fig.3).

Fig. 3. Predators: a) Apertochrysa astur, b) Cybocephalus indicus, c). Jauravia pallidula

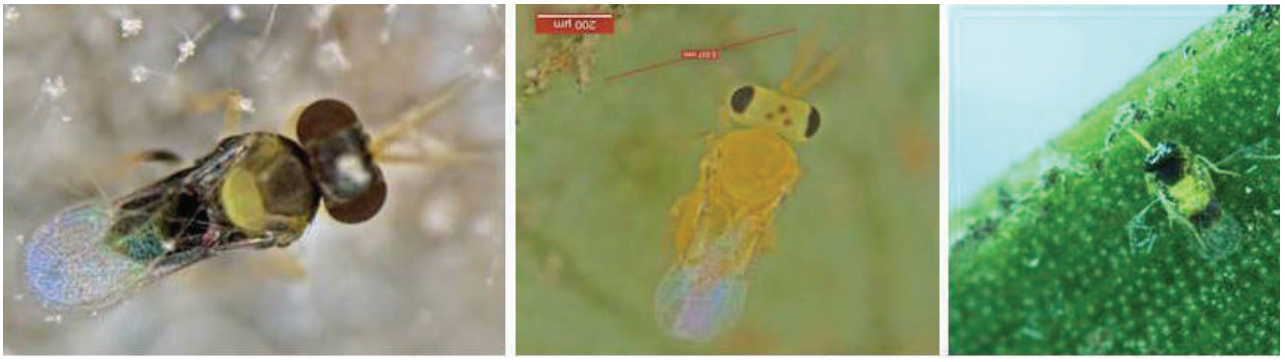

Fig.2 Parasitoids: a) Encarsia guadeloupae, b) Encarsia dispersa, C) Encarsia cubensis

In addition, a species of entomopathogenic fungus, *Isaria fumosorosea* (Hypocreales: Clavicipitaceae) was found to be effective against all the life stages of these invasive whitefly species. *Isaria fumosorosea* is highly pathogenic to the egg and early nymphal instar stage with mortality up to 91% in these stages and up to 80% mortality in the late nymphal instar stages (Fig.4).

Fig.4. Isaria fumosorosea infection on a) A. rugioperculatus, b) A. atratus, c). P. bondari, d) P. minei

Re-distribution/re-introduction of parasitoids: Non-native species can achieve invasive pest status when they are accidentally introduced to areas where they are separated from their potential natural enemies and if local (indigenous) beneficial species (predators and/or parasitoids) are unable to suppress pest population. Moreover, pests mostly disperse during egg stage from infested area to uninfested areas through seedlings results detachement of natural enemies from the host as this parasitoid parasitize on second instar nymphs.

Since natural enemies, particularly *E. guadeloupae* and *E. cubensis* were found to be suppressing the population of *A. rugioperculatus*, *A. dispersus* and *A. atratus*, effectively; farmers and other stakeholders were advised to re-distribute/re-introduce the parasitoids wherever they were absent or found in inadequate numbers by using field insectary techniques such as strategically placing the field collected parasitized nymphs in, on or next to infested vegetation for augmentation (Fig.5).

These redistribution was advocated through a plastic container (35 cm height x 25 cm width) where top and side provide with wire mesh (50-60 micron) which allow to escape parasitoid adults from the container but not whitefly adults (Fig.5). This way, we can avoid the distribution of pests and enhance the *E. guadeloupae* and *E. cubensis* population in the field. Parasitoid, *E. guadeloupae* was introduced accidently to India along with *A. dispersus* in 1990s.

Fig.5. Re-distribution techniques for parasitoid, Encarsia guadeloupae and E. cubensis

Conservation strategies for parasitoids

Conservation biological control is the implementation of farm practices that maintain and enhance the reproduction, survival, and efficacy of natural enemies of pests. Approaches to conservation of these natural enemies involve avoidance of practices harmful to them, as well as adoption of practices that benefit them. Like other animals, insect natural enemies require food, water, and shelter, and protection from adverse conditions. One strategy to improve biological control by resident natural enemies is enhancing habitat diversity through the provision of semi-natural vegetation in or around agricultural field.

Fig.6. Coconut intercropping with banana (a) and Parasitod releasing technique (b)

During the initial stage of invasion of these pests, few farmers resorted to spraying of chemical pesticides to control but their efforts were in vain as the chemicals turned out to be a temporary fix. The pest resurgence was observed in pesticides sprayed garden. Subsequently, growers advocated not to spray any pesticides for the management of these exotic whiteflies and pesticides holiday declared. In areas where chemicals were not applied, parasitoids population were observed to have multiplied rapidly and natural parasitism increased phenomenally thus preventing severe outbreaks. Therefore, frequent monitoring of the pest occurrence was done so as to conserve the natural enemies.

Banana and *Canna indica* were found to be harbouring maximum parasitoids population at field as well as in net-house condition (Fig. 8). The growers were advised to grow these plants as banker plants in coconut garden as intercrop or border crops for

Fig.7. Monitoring of whiteflies and their natural enemies

Fig.8. Canna indica as banker plant for conservation of E. guadeloupae

conservation and augmentation. The main function of these banker plants are the supporting of natural enemies reproduction and therefore the maintenance of their populations. Natural enemies can reproduce such that their numbers increase on alternative hosts or prey on banker plants, and the pests are not found on crops.

ICAR-NBAIR is striving hard to sensitize and popularize the augmentation (re-distribution, inoculative & innudative release) and conservation strategies (pesticide holiday & habitat manipulation, awareness program) for these potential biocontrol agents in collaboration with line departments, Krishi Vigyan Kendras and farmers producing organizations. To popularize these biocontrol technologies among the stakeholders, ICAR-NBAIR is imparting training on mass production protocol for these biocontrol agents against these invasive whiteflies and various augmentative and conservation strategies for these biocontrol agents.

Effect of *Isaria fumosorosea* on invasive whiteflies

ICAR-NBAIR has identified a promising fungal entomopathogenic strain of *Isaria fumosorosea* (ICAR-NBAIR pfu-5) for the management of *A. rugioperculatus, A. atratus, P. minei* and *P. bondari* in coconut. This fungus was found to be very effective with longer shelf life, persistence, host specific to the target insects and self-multiplicative capacity under natural favourable conditions. Once applied, they can grow on the insect surface exponentially and cause rapid killing of target insects.

Based on laboratory bioassays and multi-locational field evaluation, *I. fumosorosea* found to be effective in killing all the life stages of these pests in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. The eggs and early nymphal instar mortality was up to 91% and the late nymphal instars and pupal mortality was up to 80%. Mass production technology for this fungus has been standardized using solid state fermentation (broken rice grains) and liquid state fermentation technology (Sabouraud dextrose yeast extract broth & Potato dextrose broth media).

Talc, rice grain and oil formulations have been developed with longer shelf life. Due to its high field efficacy there is a huge demand for this fungus from the coconut farming community. Farmers in Andhra Pradesh are regularly trained on farm level production of this fungus using rice grains as a substrate for their use in the coconut gardens. Further, studies on standardization of liquid fermentation technology for mass production of *Isaria fumosorosea* is under progress.

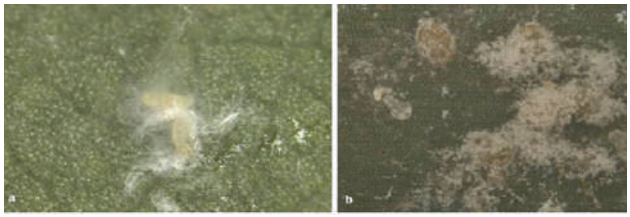

Fig.9. Isaria fumosorosea infection on A. rugioperculatus A. eggs, B. Third & fourth instar nymphs

Socio-economic impacts of biological control of invasive whiteflies

The impact of biological control was clearly evident in the pest affected coconut gardens after six months after innundative release of parasitoids, *Encarsia guadeloupae* and *E. cubensis* and foliar application of *Isaria fumosorosea.* The release parasitoids

Fig.10. Different formulations of Isaria fumosorosea (PFU-5)

successfully established and regulated the invasive whiteflies population. The pests population has come down (less than 10 live colony/leaflet) substantially in the entire severely infested coconut garden. Further the self-perpetuating parasitoids prevented the spread to neighboring garden also. The joint efforts of the various organizations weaned and prevented the farmers from resorting to use of hazardous insecticides like monocrotophos, Imidacloprid and Buprofezin in the coconut garden. Keeping in view of chemical intervention cost i.e minimum two sprays of chemical insecticide were compared with two release of parasitoids and two sprays of *Isaria fumosorosea,* we analysed the cost benefit ratio. Economic analysis on the impact of biological control revealed about Rs 9500/ha crop protection cost and 900 ml of pesticides/ ha are being saved. Further, this per hector benefit may be correlated with total areas affected by the invasive whiteflies in India gives the overall saving due to biological control intervention.

Challenges and way forward

These whiteflies are highly invasive, mobile and capable of spreading very fast from one location to another location. Available evidence suggests that new infestations have often resulted from transportations of infested plants. Chemical control is not practicable because of the abundance of host plants and wide spread distribution. It is fortunate to note that biological control agents can readily reduce the spiraling whitefly, rugose spiraling whitefly and palm infesting whitefly populations to sub-economic numbers. It would seem to be highly desirable to augment and conserve the host specific natural enemies *Encarsia guadeloupae* and *E. cubensis* to any locality seeking biological control. Moreover it is imperative to mention that correct and timely identification of this complex is very essential for carrying out further studies on their bioecology, population dynamics on different environments and development of management strategies especially biocontrol programs. There is urgent need to document a potential natural enemy complex or introduce from their native countries to develop efficient biocontrol management strategies for nesting whiteflies. Further, a nation-wide surveillance programme is required to mapping of the potential areas of its distribution, and host range to prevent further spread by restricting the exchange of planting materials.

Awareness, early detection of invasive species and immediate implementation of biological control methods could minimize the economic losses caused by the invasive whiteflies. Presently control strategies rely heavily on the augmentation and conservation of parasitoid, *Encarsia guadeloupae* and E. cubensis, foliar application of, *I. fumosoroea* and periodic release of predator, *Apertochrysa astur.* These biocontrol agents are more effective in suppressing these invasive whiteflies infesting coconut when implemented in integrative approach. *I. fumosorosea* may be successfully integrated with the augmentation and conservation of *E. guadeloupae* to achieve long term pest suppression of this notorious pest in coconut. *Isaria fumosorosea* is also effective against other invasive whitefly species like nesting and palm infesting whiteflies. Further, spraying in coconut plantation is major constratins, therefore, studies on aerial spraying using drone and dispersing *I. fumosorosea* using whiteflies adults through horizontal transmission.

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Mid whorl yellowing of coconut: a serious concern of coconut farmers

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Coconut, one of the main agricultural crops in Kerala, directly and indirectly forms the major source of livelihood for lakhs of farming families. Many pests and diseases affecting coconut palms cause widespread crop damage leading to huge economic losses. Rhinoceros beetle, red palm weevil, eriophyid mite, whitefly, black headed caterpillar, bud rot, root (wilt), stem bleeding, ganoderma wilt, inflorescence blight nut fall and leaf rot are the major pests and diseases of coconut resulting in considerable monitory losses.

In the recent years, coconut farmers of the state are facing another threat, the mid whorl yellowing / lethal yellowing disease of coconut. The disease was first seen in the districts of Thiruvananthapuram, Kollam and Pathanamthitta in southern region of Kerala in 2010. The disease spread to Thrissur, Wayanad, Kannur and Kasargod districts over a period of last 10 years. Coconut palms infected with mid whorl / lethal yellowing die within 2 years. In a purposive survey conducted across Kerala, it has been found that the disease is equally prevalent in all types of soils even in coconut gardens with good management practices.

Symptoms

The disease affects coconut palms of all ages. However, disease symptoms are mainly seen in palms that are 10 to 25 years old. It affects all tall and yellow dwarf varieties of coconut. The first visual symptom on infected bearing coconut palms is the premature nut fall/fruit drop. Most of the fallen nuts have brown to black water-soaked regions under the calyx (Figure 1). Sometimes the farmers may believe that these sudden nut falls from apparently healthy palms is due to the deficiency of certain micronutrient in the soil. This nut fall is followed by blackening/necrosis of newly emerging inflorescences. Most of the male flowers will be dead, and there will not be any fruit set in the affected inflorescences (Figure2). In short, the vitality of the reproductive system is adversely affected in the diseased coconut palms. Inflorescence necrosis, shedding of female flowers and pollen sterility render the palm unproductive.

As the inflorescence necrosis phase progresses, yellowing of the leaves starts from the leaves in the middle whorls, advancing upwards, affecting the younger and finally the upper leaves. In the initial stages of yellowing, the infected palms can be differentiated from symptomless palms from a far distance through the presence of the characteristic middlewhorl yellowing (Figure 3). Leaf yellowing, the most conspicuous symptom starts in a peculiar manner (Figure 4). Initially the yellowing occurs only in tip leaflets of the middle whorl and it progresses towards the basal leaflets. The either side of the leaf let midrib remains green and the rest of the leaf lamina turns in to golden yellow colour (Figure 5). The yellow leaves turn brown and dry. The dried leaves remain hanging on the crown for few days before fall down (Figure 6). Eventually, the whole crown perishes, leaving a bare trunk or 'telephone pole'. Mid whorl yellowing is quite different from root (wilt), which cause widespread crop damage in southern Kerala, and has the symptoms like inflorescences necrosis, shedding of immature nuts and flaccidity, ribbing, marginal yellowing and necrosis


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of leaflets, rotting of root tips and leaf rot. Root (wilt) is a debilitating disease and takes many years to kill the palms. On the contrary, the mid whorl yellowing disease leads to the complete fall of immature nuts from affected palms and make them sterile. The infected palms do not produce symptoms like flaccidity / ribbing of leaves, leaf rot and rotting of root tips.

Etiology

Symptoms of mid whorl yellowing disease are similar to the phytoplasma disease called lethal yellowing, which is found in coconut palms in African and American continents. Recently, phytoplasmal lethal yellowing of coconut has been reported in Tamil Nadu. The College of Agriculture, Vellayani and Coconut Research Station, Balaramapuram under Kerala Agricultural University have launched comprehensive research projects to identify the causal organism of mid whorl yellowing disease in Kerala.

Control measures

- Remove and destroy the diseased coconut palms along with roots.
- Plant resistant cultivars like Chowghat Green Dwarf, Malayan Green Dwarf and other hybrid seedlings having these cultivars as one of the parent.
- Ensure the good health of coconut palms by adopting integrated and balanced fertilizer management using both organic and chemical fertilizers.
- Apply 1 Kg lime/dolomite, after receiving the summer rain.
- Add 50 kg of organic manure (dung, green manure, compost) annually.
- Apply fertilizers for coconut palms in average management at the rate of 340 g N (urea 740 m), 170 g P2O5 (rajphos 1060) and 680 g K2O (Murate of Potash 1330 gm) per palm per year.


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- Apply fertilizers and manures in 10 cm deep circular basins at a radius of 1.8 to 2.0 m from the bole of the coconut palm
- Under rainfed conditions apply fertilizers in 2 splits, 1/3 in June - July and 2/3rd during the month of September - October. Under irrigated conditions apply fertilizers in four equal splits during March-April, June-July, September-October, December-January
- Along with the second fertilizer dose application, 1 kg magnesium sulphate should be applied. Apart from that, 250 g of micro nutrient mixture should also be applied
- Adopt inter cropping, mixed cropping, mulching with coconut husk, husk burial and cultivation of leguminous pulse crop.
- Adopt timely plant protection measures for the management of pests and diseases.


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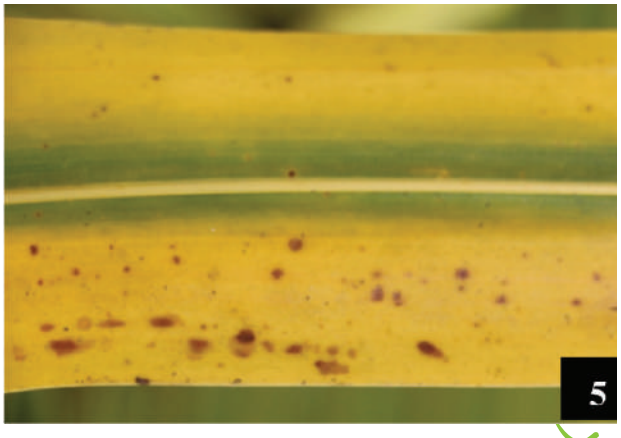
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Conservational biological control approach of Rugose Spiraling Whitefly

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Introduction:

Coconut, *Cocos nucifera L*., commonly known as "KalpaVriksha" and it provides livelihood to billions of people across the world. Coconut is grown in 93 countries. Indonesia, Philippines, India, and Sri Lanka together accounting for 78 % of the total world production. In India, the four south Indian states namely Kerala, Tamilnadu, Karnataka and Andhra Pradesh account for around 90% of the coconut production in the country. Coconut is attacked by at least 830 insect and mite species, 173 fungi and 78 species of nematodes, significantly affecting its productivity. In AP, among the insect pests rhinoceros beetle *Oryctes rhinoceros Linnaeus,* red palm weevil, *Rhynchophorus ferrugineus Olivier*; black headed caterpillar, *Opisina arenosella Walker* and coconut slug caterpillar *Macroplectra nararia* Moore together with the invasive pests viz., coconut eriophyid mite, *Aceria guerreronis Keifer*, rugose spiraling whitefly, *Aleurodicus rugioperculatus Martin* and Bondar nesting whitefly, *Paraleyrodes bondari Peracchi* are pests of major significance .

In India Invasive pest, rugose spiraling whitefly (RSW) was reported for the first time in coconut trees in Pollachi, Tamil Nadu and Palakkad, Kerala during 2016.In Andhra Pradesh RSW was first reported in Kadiyam nurseries during 2017 and from Dr.YSRHU-HRS, Ambajipeta in 2019. This pest was later reported in various other horticultural crops such as mango, guava, sapota, custard apple and banana plants, as well as on many other economically important ornamental plants. Rugose spiraling whitefly feeding on leaves leads to stress to the host plant by removing water and nutrients and development of sooty mould on upper surface of leaves due to production of honeydew which can reduce photosynthesis of the plant with consequent reduction of yield too.

Spraying of insecticides on coconut palm is difficult due to habitat of the most coconut pests, tall height of the palms and various edible intercrops. Further, use of insecticides for the management of these pests is being discouraged due to their deleterious effects on pollinators and other natural enemies in the coconut ecosystem thereby providing immense scope for the biological control.

Rugose spiraliing whiteflies on coconut in Andaman

Bio-control agents viz., *Bracon brevicornis, Goniozus nephantidis* (against coconut black headed caterpillar), *Pediobius imbrues* (against coconut slug caterpillar) and *Apertochrysa astur* (against rugose spiraling whitefly) are already being used by the plantation farmers and widely commercialized from the bio-control laboratory of Dr. YSRHU- HRS, Ambajipeta for the management of insect pests in coconut.

Encarsia guadeloupae a potential parasitoid on Rugose Spiraling Whitefly:

The parasitoid *Encarsia guadeloupae* was reported as a promising bio agent against RSW. This parasitoid migrated from the Maldives into Minicoy and other islands of the Lakshadweep in 1999 and later, assisted by the intentional release and colonization, spread to other areas of peninsular India. It is also reported that the parasitoids were found only after their numbers increased phenomenally through breeding for several years on the expanding host population, although they had been introduced along with the host *A. dispersus.*

Introduction and Conservation of *E. guadeloupae* in Andhra Pradesh:

In Kerala and Tamil Nadu parasitisation range of *E. guadeloupae* was reported from 40 to 70% in banana and 20-60% in coconut on RSW. Intensive surveys carried out by scientists of Dr. YSR Horticultural University in the year 2017 to find the *E. guadeloupae* parasitisation in RSW infested Coconut, Oil palm plantations and nurseries of Kadiyam area in Andhra Pradesh revealed that *E. guadeloupae* parasitisation on RSW was not observed. Hence, with an objective of establishing *E. guadeloupae* the scientists of Dr. YSRHU - HRS, Ambajipeta brought *E. guadeloupae* parasitised white fly pupal stages from TNAU (Tamil Nadu Agricultural University), Aliyarnagar, Tamil Nadu and ICAR-CPCRI, Kasargod, Kerala and ICAR- NBAIR, Bengaluru, Karnataka in a phased manner. The first consignment of 1500 numbers of parasitised white fly pupal stages were released in coconut gardens in Kalavalapalli village of West Godavari district on 18.12.2017 and second consignment of 2500 numbers were released in Oil palm and Coconut gardens on 08.01.2018. These attempts resulted in approximately 72 % field level parasitisation of RSW by *E. guadeloupae.* However *Encarisa* establishment though satisfactory upto March was affected in subsequent months due to higher temperatures In 2018, September *E. guadeloupae* parasitised white fly pupal stages were obtained and re- released in RSW infested coconut gardens and these attempts resulted again in parasitisation of RSW by *Encarsia* (62 per cent). Consignments of *E. guadeloupae* were obtained from TNAU on 2.11.2019 (1500 number parasitised white fly pupal stages) and from ICAR-NBAIR Bangalore on 12.12.2019 (1400 number parasitised white fly pupal stages) and 24.12.2019 (1600 number parasitised white fly pupal stages) and released in identified Goutami Ganga (dwarf variety) block in the research farm (Table-1).

Table1: Source and Number of Encarsia guadeloupae parasitised RSW pupae obtained and released in Andhra Pradesh from 2017 to 2019

Year	Source	Number of E. guadeloupae parasitised RSW pupae obtained
December, 2017	TNAU, Aliyarnagar, Tamil Nadu and ICAR-CPCRI, Kasargod, Kerala	1500*
January, 2018	TNAU, Aliyarnagar, Tamil Nadu and ICAR-CPCRI, Kasargod, Kerala	2500*
November, 2019	TNAU, Aliyarnagar Tamil Nadu	1500**
December, 2019	ICAR- NBAIR, Bengaluru, Karnataka	1400**
December, 2019	ICAR- NBAIR, Bengaluru, Karnataka	1600**

**- Released at Kalavalapalli village of West Godavari district.*

*** -Released at Dr.YSRHU-HRS,Ambajipeta of Dr.B.R.Ambedkar Konaseema district.*

The parasitoid population increased and about 48% percent parasitisation was observed even after summer 2020 which increased subsequently to 88% in December during which period RSW population is favorably building up. In 2021, *E. guadeloupae* acclimatized and established to the local environmental conditions (Parasitisation range 28.92-83.19%) with the peak parasitisation observed in the month of January. Further, in the summer months the parasitoid population did not dwindle and parasitisation percentage of 59.71 % and 34.92% was observed during the months of April and May, 2021.

Starting from January 2021, 15000 *E. guadeloupae* parasitised RSW pupae leaf clippings (Each clipping containing 3-5 parasitised pupae) were re-distributed to the coconut plantation growers from East Godavari, West Godavari, Vishakapatnam and Srikakulam districts for the successful establishment of this parasitoid in those regions. Subsequent surveys in 2022 in these districts revealed successful *E.guadeloupae* colonization in RSW infested gardens in the redistributed areas.

In 2022, *E. guadeloupae* parasitisation in the range of 19.14 - 48.25% was observed at Dr. YSRHU-HRS, Ambajipeta farm inspite of re-distribution of parasitised RSW pupae leaf clippings in 2021 indicating that once established *E. guadeloupae* can successfully sustain itself in the released plantations. As parasitism levels of *E. guadeloupae* were found to be highly density-dependent the buildup of RSW will increase parasitisation by *E. guadeloupae* proportionately (Table-2).

Month Percent rugose spiraling whitefly pupae parasitised by E. guadeloupae					
Sl No.	2018	2019	2020	2021	2022
January	20.01	71.35	4.22	83.19	27.44
February	72.06	65.44	1.49	80.19	34.65
March	52.81	28.68	9.88	74.94	37.25
April	Nil	11.41	18.50	59.71	24.35
May	Nil	8.17	27.81	34.92	20.21
June	Nil	2.53	36.36	31.04	19.14
July	Nil	Nil	47.60	28.95	26.54
August	Nil	Nil	72.71	43.72	32.54
September	29.34	3.39	78.47	39.78	34.75
October	42.38	4.91	66.80	35.11	38.65
November	69.49	7.70	79.71	32.04	42.58
December	68.83	9.75	88.08	28.92	48.25

Table 2: Establishment of parasitoid E. guadeloupae in Kalavalapalli village and Dr.YSRHU-HRS., Ambajipeta from 2018 to 2022.

Measures to conserve parasitoid *E. guadeloupae*

Conservational biological control can be promoted through non usage of pesticides. Hence creating awareness among farmers about deleterious impact of pesticide usage is vital. Among the various intercrops grown in coconut broad leaved plants like Colacasia and Banana which are also alternate hosts of RSW are supporting the development of *E. guadeloupae*. Further it was earlier reported that ornamental plant *Canna indica* served as reservoir plant enhancing the multiplication of parasitoid *E. guadeloupae*. Therefore promotion of intercropping with Colacasia, Banana and border planting with C. indica will conserve this potential parasitoid and successfully managing RSW through conservation biological control. Further studies on off season survival of *E. guadeloupae* needs to be explored especially under low RSW population levels. Redistribution of *E. guadeloupae* parasitoid infested RSW pupae leaflets will help in faster spread of the parasitoid and can regulate RSW successfully in newly spread areas.

Conclusions:

From the present studies, it is found that successful management of rugose spiralling whitefly can be achieved through conservational biological control approaches viz., release of *E. guadeloupae* parasitized RSW pupae in RSW infested coconut plantations and its further re-distribution leads to successful colonization and establishment. Hence, intensive surveys for presence of this parasitoid has to be carried out and where its population is low systematic redistribution can effectively suppress RSW population there by promoting biological control based pest management.

AAHAR

Coconut Development Board, MDIC, New Delhi participated in 37th AAHAR - Internatioanl Food & Hospitality Fair held from 14th – 18th March 2023 at Pragathi Maidan, New Delhi. Board displayed various value added coconut products viz Packed Tender Coconut Water, VCO, Edible Coconut Oil, Coconut chips, DC powder, Coconut Milk, Milk Powder: informative posters on CDB schemes, goodness of coconut and publications of the Board. 12 coconut based entrepreneurs displayed their products and services in the Board's stall.

Global Coconut Industry

– on the cruise to reach greater heights

The global coconut industry had converged in the ancient city of Hyderabad during 27-28 February 2023 to discuss on the way forward for this sunrise industry. The International Conference on Trade and Marketing of coconut products was hosted by India with the objective to discuss on the international outlook for coconut products and the strategies and policies that will lead to the sustained development of the sector benefitting both the farmers and the industry.

Coconut Development Board(CDB) functioning under the Ministry of Agriculture and Farmers Welfare, Government of India had collaborated with the International Coconut Community (ICC) in organizing this important event. The Conference was inaugurated by Dr. Vijayalakshmi Nadendla IAS, Chief Executive Officer, CDB in the presence of Dr. Jelfina C. Alouw, Executive Director, ICC; Dr. Reghunandan Rao IAS, Principal Secretary and Agriculture Production Commissioner, Govt. of Telengana; Mr. Bernie Ferrer Cruz, ICC Philippines National Liaison Officer and Administrator of Philippine Coconut Authority; Dr. P. Chandra Shekara, Director General, MANAGE and Dr. Ramesh Mittal, Director, CCS NIAM, Jaipur. The Conference was attended by around 120 participants physically and over 500 participants virtually from nearly 30 countries across the globe. The participants included farmers, entrepreneurs, exporters, subject experts , researchers, scientists, policy makers and other stakeholders.

Inaugural programme

In her opening address, Dr. N. Vijayalakskmi IAS, CEO, briefed that, as per 2020 statistics of ICC, India is the largest coconut producing country in the world, with 30.93% share of global production, followed by Indonesia and Philippines. India ranks second in terms of productivity i.e. 9,346 nuts per ha next to Vietnam 10,547 nuts per ha. The coconut crop contributes around Rs. 307,956 million to the country's GDP and earns export revenue of around Rs. 75, 768.80 million. The potential and prospects of this crop could be utilized and sustained development of the sector achieved through proper market analysis, market development and expansion. She informed that the Board undertakes market promotion activities for the promotion of coconut products in the domestic and export market.

Dr. Jelfina C. Alouw, Executive Director, ICC, in her address stressed about facilitating the transfer of technical information on global market prospects in coconut, innovative industry in coconut sector and sustainability in coconut sector. She expressed her sincere gratitude to the eminent resource speakers from Indonesia, Philippines, Sri Lanka, ITC, Geneva; LMC International Malaysia; Oil World, Germany; and Fairfood Netherlands for participating in the conference and sharing their outlook on the prospects for the sector in the days to come.

Dr.Reghunandan Rao IAS, Principal Secretary and APC, Govt. of Telengana in his address pointed out that, Telengana has invested heavily on agriculture and there is a tremendous growth in the crop, coconut. He informed that the State is shifting from field crops to plantation crops. Mr.Bernie Ferrer Cruz, ICC National Liaison Officer and Administrator emphasized the importance of coconut sector, which needs a breakthrough in market research, quality of coconut value added products, digital marketing.

During the occasion, the Diamond Jubilee issue of Indian Coconut Journal was released and an MOU was signed between CDB and National Institute of Agricultural Extension and Management (MANAGE) and National Institute of Agricultural Marketing (NIAM) for carrying out market research activities and FPOs. Dr. Hanumanthe Gowda, Chief Coconut Development Officer proposed vote of thanks.

International outlook for coconut products

The speakers in the first session, chaired by Mr. Asep Jembar Mulyana, CEO PT Tom Cococha, Indonesia, spoke in detail on the international outlook for coconut products. The multiple factors which have contributed to the weakening of coconut and coconut oil prices includes the pandemic, the ongoing war, increased stock of copra and coconut oil in major coconut producing countries due to the disruption in supply chain, increased freight charges and the logistic costs, shortage in containers etc.

Dr. Julian Conway Mc Gill, Head South East Asia LMC International , Kuala Lumpur, Malaysia presented a paper on International Lauric Outlook with special emphasis on coconut products and oleochemicals. He opined that coconut oil has distinct functional and sustainability advantages over palm kernel which needs to be highlighted to gain an advantage in the global market. The slump in the oleochemical industry, the reduced demand and substitution with alternatives need to be addressed by promoting coconut oil as a sustainable product. Mr. Nagaraj Meda, CMD, Transgraph Consulting Pvt Ltd, India presented the global economic situation and the ensuing slowdown in many advanced countries, the potential of India emerging as a significant economic power and the general outlook on the coconut products in the global market.

Mrs. Yvonne Agustin, Executive Director, United Coconut Association of the Philippines presented the coconut situation in the Philippines and the need to reach out to new markets and target other developing countries for coconut products. The export scenario of coconut products in the Philippines was also explained. Mr. Siegfried Falk, Co-Editor, Oil World International, Germany presented the Oil World perspective of global supply, demand and price outlook for coconut oil. The general conclusion was that while prices can be inflationary, demand for coconut products will continue since it is an ingredient in several consumer goods. It is expected that the market conditions will soften demand but there will always be a tendency to stage a rebound as proven in the past. Dr. P. Chandra Shekara, Director General, MANAGE, India presented the topic Market Led Extension: Learnings for Coconut Industry in which the extension initiatives in the agriculture sector in India were explained.

Moving towards sustainable coconut sourcing

This session was felt as the need of the hour since there were issues in sustainable sourcing of coconuts for processing in many countries. Adding to it was the increasing proportion of unproductive and senile palms. A healthy partnership between industry and farmers is a requisite not only for sustainable sourcing of coconuts, but also in the transition towards sustainable agriculture.

The session was chaired by Dr. Ramesh Mittal Director, CCS National Institute of Agricultural Marketing (CCS-NIAM), India. The presentation of Mr. Bernie Ferrer Cruz, Administrator, Philippine Coconut Authority(PCA) was presented by the official from PCA. The options discussed included simplification of the supply chain linking the producer directly to the processors. Sustainability of the consumer and building everlasting trust with them through certification was another way ahead which will also ensure sustainability in the production process. Mr. Heru Tri Widarto, Secretary, Directorate General of Estate Crops, Ministry of Agriculture, Indonesia shared his experiences with the Indonesian coconut sector. The introduction of sustainability standard encompassing productivity, conservation, livelihood security and socioeconomic and ecological sustainability was felt to be a viable option which is also in tune with the Sustainable Development Goals(SDG). Expanded partnership of public and private sector and delivering targeted improvements for the small holders in the supply chain may work out as an effective mechanism in ensuring and uplifting the standards.

Mr. R. R. Shrinivasan, Managing Director of Apex Coco & Solar Energy Limited, India presented his practical experiences in operating the biggest integrated coconut processing unit in India. He opined that coconut industry should capitalize on the qualities of coconut as an ideal source of a plant based, vegan, gluten free, dairy free zero waste food. He also stressed the need for the ICC to take up the nomenclature of coconut as a nut when scientifically it is not a nut, but a fruit. The issue of allergens in coconut based on its referral as a nut is creating issues in the global market. He urged for community action on the goodness of Medium Chain fatty acids and saturated fat. Mr. Samidh Shrestha, Analyst, International Trade Centre, Geneva, Switzerland spoke on the Strategies for Overcoming Tariff and Non-Tariff Barriers. The market friction through the non tariff measures, the lack of market transparency, seasonality and price-quality mismatches need to be addressed.

Global market Prospects and Growth Prospects for coconut products :

The third session was chaired by Dr Julian Conway McGill, of LMC International, Kuala Lumpur. Mr. Asep

Jembar Mulyana, CEO of Pt. Tom Cococha shared his industry experiences with coconut briquettes. Coconut produces environment friendly products and use of charcoal in briquettes contributes to Coconut Economic Diplomacy – charcoal saves forests and is economically superior to alternate forms of energy. Mr. Ferdinand Dela Cruz, CEO and Chief Sustainability Officer representing one of the oldest coconut processing units in the world, Franklin Baker Co., Philippines presented his experiences with the sector. Market developmental; efforts should be oriented to target the seven drivers of consumer behaviour which include well being, technology, rights, value, experience, identity etc. Innovation, sustainability, quality and reliability are the growth drivers in the emerging markets.

Mrs. Peyanoot Naka, Vice Chairman Conservation and Development of Coconut Oil Forum of Thailand (CDCOT) shared the industry experiences in Thailand and called for personalization and targeted advertising. The growth experienced across the globe for organic skin care products was remarkable and concentration should be in the health and beauty care segment for coconut products. Mr. Suresh Silva, CEO of Silver Mills, Sri Lanka urged that the major entrepreneurs and exporters of coconut products in the major coconut growing countries should collaborate and undertake joint action in identifying new markets and establishing market development linkages. He shared his experience of penetrating the Russian market by developing interesting recipes and integrating coconut in the Russian menu. He stressed the need for changing according to the change in the communities and consumers. Coconut milk is the next alternative for dairy which is a large market segment. Around 25% of the coconut production is required for substituting 4% of the market for dairy products with coconut milk. The potentials for such market development is enormous and collaborative action for market development among industries in ICC member countries will help emerge successful. Dr. Ramesh Mittal, Director, CCS National Institute of Agricultural Marketing (CCS-NIAM), India made a presentation on Supply Chain Dynamics for Coconut Products.

Innovative Industry Practices application of technology in coconut sector.

The session was chaired by Dr. P Chandra Shekara, Director General, MANAGE, India. Dr. Manish Pande, Director and Head, Quality Council of India spoke on Relevance of Quality Certifications in Global Market. He called for development of Coconut GAP anmd benchmarking with international practices. Mr. Sudeesh Narayaran, Technical Head, TRACE, Fairfood, Netherlands presented the application of Block Chain Technology in Coconut.

Mr. Dian Martin, Chairman of Indonesia Digital Marketing Association made a presentation on Digital Marketing- Prospects and Challenges. Use of innovative technological applications in marketing connects the farmers to the supply chains digitally and leads to enhanced transparency, traceability and accountability. Enhanced trust on part of producer and consumer leads to premium prices and assured returns. Mr. Arun V, Head- Copra Buying, Marico Ltd. India presented the details of the programme, "Kalpavriksha" which targets at inclusive development of the coconut sector with the industry partnering with the farmers and both growing together.

The take aways

The International Conference ended on a positive note with a realization that the weakening of prices is a global phenomenon and increased optimism and hope for the rebounding of the market in the days to come. The event gave ample opportunity for the participant entrepreneurs and exporters in building new networks, creating collaborative partnerships and efforts for integration of technology for the sustained development of the sector. The Community unanimously agreed for the need to get together, in unison, to fight the negative propaganda against coconut products. Need for a diversification of focus markets and innovation in products was very much felt by the participants. The tour in the evening to catch glimpses of the beautiful ancient city of Hyderabad gave opportunity for pleasure and recreation with new bonds developed between countries. Ultimately it was triumph for the Tree of Life.

Released Diamond Jubilee issue of Indian Coconut Journal

Indian Coconut Journal published by Coconut Development Board completed 75 year of its publishing during January 2023 . A Diamond Jubilee issue of the Indian Coconut Journal was published and released during the inauguration of the International Conference on Trade and Marketing of Coconut Products held on 27th February 2023. Dr. Vijayalakshmi Nadendla IAS, Chief Executive Officer, CDB released the Diamond Jubilee issue.

CDB organized Naariyal Mela at its DSP Farms

DSP Farm, Kerala

Coconut Development Board conducted Coconut Mela at DSP Farm, Neryamangalam on 7th March 2023. Smt. Resmi D. S, Deputy Director, CDB inaugurated the Mela. Smt. Mini Mathew, Assistant Director Publicity & Public Relations, Shri. J. George Peter, Development Officer and Shri. Babu Varkey, Senior Field Officer spoke during the occasion. Dr. Abdul Harris, Principal Scientist, CPCRI Kayamkulam and Dr. M. Shareefa, Senior Scientist, CPCRI interacted with farmers about the future of coconut farming and new farming methods. A visit to Neriyamangalam farm for farm journalists was also arranged as part of the Mela. An exhibition of coconut value added products was held at the venue. Around 100 farmers attended the programme.

DSP Farm, Tripura

Coconut Development Board, DSP Farm, Tripura conducted Nariyal Mela on 9th March 2023. Shri. Mailafru Mog, MLA, Manu Constituency inaugurated the Mela. Shri. B. Chinnaraj, Farm Manager CDB and Shri. Sourav Saha, Agriculture Sector Officer spoke during the occasion. Around 120 farmers attended the mela.

DSP Farm, Odisha

Coconut Development Board, DSP Farm, Pitapally, Odisha organized Nariyal Mela, at DSP Farm, premises on 13th March. The Nariyal Mela was inaugurated by Dr. Gobinda Chandra Acharaya, Principal scientist, Indian

Institute of Horticulture Research, ICAR , Bhubaneswar. Dr. Nidhucezhian, Head & Dr. Susanta Kumar Jata Farm Superintendent CTCRI, Bhubaneswar, attended the Nariyal Mela. An exhibition with literature on schemes and programme of the Board, value added products and coconut handicrafts were exhibited in the Nariyal Mela. Around 125 persons including farmers, press reporters and state govt. officials participated in the Nariyal mela. Dr. Acharaya briefed on medicinal value of coconut, and Dr. Nidhucezhian spoke about intercroping in coconut garden. Shri Rabi Narayan Das, Development officer, CDB delivered the welcome address and Shri Manoranjan Panda, proposed the vote of thanks.

DSP Farm, West Bengal

DSP Farm, Fulia organised Nariyal Mela on 21st March 2023 in the farm premises, Dr. Amiya Debnath, Deputy Director CDB delivered the welcome address . Shri Hrishikesh Khanra, DeputyDirector of Horticulture, Nadia dist, Shri Debabrata Basantia, Head, KVK,ICAR-NDRI, Eastern Regional Station, Dr. Sanjay Kumar Ray, Scientist (Soil Sc),ICAR-KVK, NDRI, Nadia, Dr.Soumita Pal, ADA, Shantipur block and Shri Susamoy Kundu, ADA, Dist.Seed Farm, Fulia, Nadia attended the programme. Technical session on improved coconut cultivation technologies, integrated pest & disease management and value addition prospects of coconut and farmers interactive session was held as part of the programme. Different coconut byproducts and handicraft items were displayed along with informative posters in the exhibition held as part of the programme. Around 140 participants including farmers and farm journalists actively participated in the Nariyal Mela

DSP Farm, Assam

DSP Farm Abhayapuri organized Nariyal Mela at the farm premises in Batteri, Bongaigaon on 15th March 2023. Shri Ashish Kalita Magistrate, North Salamara inaugurated the mela. Dr. Hanumanthe Gowda CCDO, Coconut Development Board was the Guest of Honour. Dr. Rajat Pal. Director. CDB R.O Guwahati briefed about the schemes of Coconut Board. Shri Bilich Dan Bara-Assistant Director, delivered the welcome address and Smt. Farin S. Shaheed, Field Officer proposed vote of thanks. Technical sessions were held on Scientific Coconut Cultivation Practices and Nursery Management by Dr. L S Singh, Scientist, CPCRI Research Institute, Kahikuchi, Guwahati and Pests and Diseases of Coconut and its Management by Dr. Dwiban Pujari, SMS Plant Protection. KVK, Bongaigaon. Exhibition on different varieties of Coconut seedlings, edible coconut products and handicraft items were held as part of the programme.

National Exhibition on Agricultural Marketing

Coconut Development Board, Regional Office, Bihar participated in National Exhibition on Agricultural Marketing 2022-23 at LNM Institute, Patna held from 4th to 7th March. Shri. S. Siddharth I.A.S, Additional Chief Secretary, Finance Department, Govt. of Bihar & Dr. Vijaya Lakshmi Nadendla, IAS, Joint Secretary (Marketing) GOI and CEO, CDB, Kochi inaugurated the Exhibition. Board displayed various informative posters on CDB schemes, goodness of coconut and publications of the Board. Various value added products viz virgin coconut oil, coconut sugar, coconut lemonade, handicraft items, coconut chocolates and cookies were displayed in Board's stall.

Impressions and Perspectives for a Prosperous Coconut Sector : VAIGA 2023

George V. Thomas

Value Addition for Income Generation in Agriculture (VAIGA) is a mega-event organized annually by Department of Agriculture Development and Farmers Welfare, Government of Kerala, with the objective of promoting and encouraging the development of value chain in Kerala's agro-sector, improving production levels and encouraging new technologies. The sixth edition of VAIGA was held at Putharikandam Maidanam, Thiruvanathapuram, Kerala, from 25th February to 2nd March 2023. An exhibition organized as a part of VAIGA 2023 provided opportunity to the entrepreneurs and Government institutions to showcase their products and machinery for value addition.

Advances in Coconut Production Technologies

A session on Advances in Coconut Production Technologies was held during the forenoon of 2nd March 2023, as a part of International Conference organized in connection with VAIGA 2023. The session was chaired by Dr. K.B. Hebbar, Director, ICAR- Central Plantation Crops Research Institute, Kasaragod and co-chaired by Dr. B. Hanumanthe Gowda, Chief Coconut Development Officer, Coconut Development Board, Kochi. Dr. George V. Thomas, Former Director, ICAR-CPCRI served as moderator for the session. Mr. George Sebastian, Director, SAMETI briefed about the objectives and programmes of VAIGA and delivered the welcome address.

Mr. P. Prasad, Honorable Minister for Agriculture graced the function with his valuable presence and discussion. The lead perspective in the session was delivered by Mr. K. Krishnan Kutty, Hon. Minister for Electricity, Government of Kerala. The minister himself is a progressive, enterprising and award winning farmer who could reach new heights in coconut production with an average yield of 150 coconuts/palm/year and a record vegetable production of 52 t/ha. The Hon. Minister attributed the success of his farming to the adoption of latest scientific technologies including precision farming techniques. He reiterated that profitability of coconut farming is coming down over the years and urgent steps are needed to save the coconut farmer from distress. Two important suggestions given by him were, to make available a portion of profit realized due to value addition to the farmer and to demonstrate the successful technologies

in farmers' fields so that the farmer gets convinced of the advantages of the technologies.

Dr. Jelfina C. Alouw, Executive Director, International Coconut Community, Jakarta, Indonesia delivered key note address on "Sustainable Coconut Industry- A Global Perspective". She presented the international coconut scenario with focus on market trends, value addition and the way forward. She emphasized the need to achieve sustainability in coconut farming with respect to economic, social and environmental dimensions. In coconut production, Philippines stands first, followed by Indonesia and India but in terms of number of nuts, India stands first. She informed that India lags behind in export of value added products of coconut except in coir and coir products. She listed the challenges in coconut sector as low productivity, low farmers income and physical capacity constraints such as low level of knowledge on scientific technologies and low support from Government. She suggested strengthening of value chains for development of sustainable, resilient and globally competitive coconut sector.

Dr. K. B. Hebbar, Director, ICAR-CPCRI, in his presentation highlighted important technologies developed by the institute on production and value

addition of coconut. He advocated the cultivation of high yielding varieties and hybrids, temperature tolerant varieties in areas where production is adversely affected by aberrations in weather and root (wilt) resistant varieties in root (wilt) diseased track. Bio-manures viz. Kalpa soil care, Kalpa gold, bio-fertilizers - Kera Probio and micro-nutrient mixture- Kalpa Poshak and Kalpa Vardhini are vital inputs to enhance soil health.There is huge potential to enhance the returns from coconut farming by product diversification. He particularly mentioned about the potential of sap based products viz., neera - a farmer can get up to 400 l of sap from a coconut palm annually and coconut sugar- having low glycemic index, to enhance the returns several fold. Virgin coconut oil and the by- products from VCO processing are other products having great promise to enhance profitability.

Dr. B. Hanumanthe Gowda, Chief Coconut Development Officer, Coconut Development Board, Kochi, in his talk informed that Kerala has an area of 7.6 lakhs hectares under coconut, which forms 30 % of the area and contributes 24 % of production at the national level. He mentioned that the coconut productivity is lower in Kerala when compared to other major coconut growing states like Tamil Nadu and Karnataka. In view of the high carbon sequestration potential, the scope to include coconut for carbon trading needs to be explored so that coconut farmers may become eligible to get incentives for growing coconut.

Other presentations were on "Value addition technologies in coconut" by Dr. Navin Kumar Rastogi, Chief Scientist, CSIR- Central Food Technological Research Institute, Mysore, "Health and nutrition aspects of coconut products and new technologies on nutri-products " by Dr. K. R. Anil Kumar, Former Scientist, Defence Food Research Laboratory, Mysore, " Coconut Wood based technologies" by Dr. E.V. Anoop, Dean, College of Forestry, Vellanikkara and "New technological advances in coconut milk manufacturing-success story" by Shri. Lithin Thomas, Managing Director, Volis Fresh Foods.

Dr. George V. Thomas, Former Director, ICAR-CPCRI and moderator, in his talk dealt with the significance of the crop in the economy of the state and livelihood security of millions of farmers. Though the crop has inherent strength as a traditional crop, it is facing challenges with respect to reduction in area, low productivity, unstable price situation, predominance of small and marginal holdings and low level of value addition. The strategy to revitalize the coconut sector should include interventions to enhance the productivity and profitability through a slew of technologies including planting of high yielding varieties and hybrids, adoption of good agricultural practices, multi-species cropping systems/ integrated farming systems and promotion of product diversification. To overcome the problems faced by small and marginal farmers with respect to scale of operation, establishment of Community Based Organizations and formation of value chains covering production, processing and marketing is suggested. There is immense scope to tap the potential of coconut based tourism in the state in view of the recent report of the strength of Kerala to become a global leader in responsible tourism.

In the open discussion, the farmers showed keen interest to know the source of planting material of high yielding varieties of coconut and they were informed about the sources including CPCRI, CDB and Department of Agriculture Farms. Some farmers also wanted to know the details of the commercially viable value addition technologies. Few farmers showed interest to know the plausible reasons for the inadequate spread of some of the value addition technologies which have high potential to increase the profitability. It was informed that though there is immense potential and technological backups, the value addition except that of coir and coir products, has not received the required momentum in India, though there are encouraging trends. More efforts are needed to make value addition an important pathway for a profitable and vibrant coconut sector.

Mr. Shibu Neelambaran, Deputy Director, SAMETI presented brief malayalam version of the presentations made by the speakers in English. Smt. Elizabeth George, Deputy Director, SAMETI and convenor of the session, proposed vote of thanks.

"Advances in Coconut Production Technologies" session in VAIGA 2023 provided a valuable platform for the stakeholders in coconut sector to converge and deliberate on the present global scenario, technological advancements, challenges, opportunities and strategies for a vibrant and sustainable coconut sector in Kerala. The research advancements available in the national and international level particularly on production and value addition aspects of coconut were well presented by eminent scientists. The interactions of policy makers, scientists, developmental officials, extension officers, farmers and entrepreneurs will go a long way to develop a resilient and sustainable coconut sector in Kerala.

Report prepared by Dr. George V. Thomas, Former Director, ICAR- Central Plantation Crops Research Institute, Vettimoottil, Vakayar Post, Pathanamthitta, Kerala, PIN-689698, INDIA

State Level Farmer's Mela -Kerala

Coconut Development Board in association with Kerala Agricultural University, Vellanikkara, Thrissur organized a State Level Farmer's Mela at Central Auditorium, Kerala Agricultural University, Vellanikkara, Kerala on 17th February 2023. Dr. A. Sakeer Hussain, Registrar, Kerala Agricultural University, Thrissur inaugurated the programme. In his inaugural address Dr.Sakeer Hussain spoke on the status of coconut production and productivity in the country and emphasized the relevance of this sector in providing employment generation. He called upon the farmers to keep themselves updated in utilizing developed technologies of the sector like ICT, IOT Artificial Intelligence etc. He added that CDB, KAU and CPCRI can work hand in hand for enhancing the productivity of coconut in Kerala.

Dr. Jacob John, Director of Extension, KAU in his keynote address spoke on the importance of multi level cropping system for doubling the farmer's income. Farm plan based production program being implemented by the state government in association with KAU is concentrating on increasing the farmer's income. Value addition and marketing are also important areas which need more attention.

Dr. B. Hanumanthe Gowda, Chief Coconut Development Officer, CDB in his presidential address said that the objective of the Board in organising Farmers Mela is to create minimum one entrepreneur in each grama panchayath of the state. Board has earmarked 30% of its total financial allotment for the integrated development of coconut cultivation and industry in the state of Kerala. He called upon the farmers to concentrate more on marketing of coconut products to generate better income from coconut farming. The need for community based approach was also emphasized for effective management of pest and diseases of coconut.

Shri. Pramod P Kurian, Deputy Director, CDB welcomed the gathering and Dr. Annena E R Associate Professor, KAU proposed vote of thanks.

Around 800 farmers from all coconut growing districts from across the state attended the programme. The meeting was followed by a Technical Session and Farmer's Scientist's interaction on various problems and prospects related to coconut farming. An exhibition showcasing innovative value added coconut products was also held as part of the programme. Coconut Development Board, CPCRI, KAU and other entrepreneurs/craftsmen displayed their products and services in the exhibition.

News

North Eastern Coconut Farmer's Meet

Coconut Development Board in association with Department of Agriculture and Farmer's Welfare, Govt. of Tripura organized North Eastern Coconut Farmer's Meet on 17th March 2023 at Rabindra Bhavan, Agartala, Tripura. Shri. Ratan Lal Nath, Hon'ble Minister for Agriculture and Farmer's Welfare, Govt. of Tripura inaugurated the programme and Shri. Meailafru Mog, Member of Legislative Assembly, Monu constituency, Tripura presided over.

Hon'ble Minister in his inaugural address called upon the farmers to adopt scientific cultivation of coconut. The minister interacted with farmers and spoke on the growing trend in the production of coconut over the years in the state of Tripura. Shri Meailafru Mog, MLA during his address congratulated Coconut Development Board for its efforts in establishing a good coconut nursery in Tripura.

Shri. Apurba Roy IAS, Secretary Agriculture, Department of Agriculture and Farmer's Welfare, Govt. of Tripura, Dr. Hanumanthe Gowda, Chief Coconut Development Officer, CDB spoke on the occasion. Shri. Saradindu Das, Director, Department of Agriculture and Farmer's Welfare, Govt. of Tripura, Dr. T. K. Maiti, Principal, College of Agriculture, Agartala, Dr. P. B. Jamatia, Director of Horticulture, Govt. of Tripura and Dr. A. K. Nandi, Advisor, Horticulture Corporation, Govt. of Tripura were the dignitories who attended the programme.

The meeting was followed by Technical Sessions, Farmer's Scientist's interaction on various problems and prospects related to scientific coconut cultivation, processing and value addition, pest disease management etc in North Eastern states. Around 700 participants including farmers and senior officials from the Department of Agriculture/Horticulture, ICAR, KVKs and Agriculture Universities attended the programme.

Kisan Mela and Agri Exhibition

Coconut Development Board, DSP Farm, Chhattisgarh participated in Kisan Mela and Agri Exhibition at Ramakrishna Mission Ashram School Ground, Narayanpur held from 10th to 11th February 2023. Board displayed various informative posters on CDB schemes, goodness of coconut and publications of the Board. Various value added products viz. virgin coconut oil, coconut sugar, handicraft items, coconut chocolates, desiccated coconut powder etc. were displayed in Board's stall.

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Cultivation practices for coconut - April

Collection and storage of seed nuts

Continue seed nut collection from the identified mother palms. Seed nuts should be carefully harvested and properly stored to prevent drying of nut water. Wherever the ground surface is hard, harvested bunch should be lowered to the ground using a rope.

Nursery management

Continue irrigation for the seedlings in the nursery. Weeding has to be done wherever necessary. If termite infestation is noted in the nursery drenching with chlorpyriphos (2ml chlorpyriphos in one litre of water) should be done. Spiralling white fly infestation is observed in coconut nurseries in many localities. Spraying of water on the lower surface of leaves of seedlings can be done against spiralling white fly attack.

Fertilizer application

In irrigated coconut gardens, apply one fourth of the recommended dose of chemical fertilizers to the coconut palms, if not applied during March.

Irrigation

Irrigation has to be continued in coconut gardens. If basin irrigation method is adopted, provide irrigation once in four days @ 200 litres per palm. Drip irrigation is the ideal method of irrigation for coconut, especially under water scarce situation. The number of dripping points should be six for sandy soils and four for other soil types.

Moisture conservation

Hot dry weather continues in most of the coconut growing tracts and scarcity of water for irrigation is going to be a major problem in coconut farming. Hence, coconut growers need to judiciously use water for irrigation. Drip irrigation has to be adopted to save water. Thick mulch need to be provided in the palm basin within two metre radius. In water scarce

areas, wherever feasible, life saving/protective irrigation has to be provided to coconut palms. Mulched materials are to be removed in the basin before giving such life saving/protective irrigation and immediately after providing irrigation the basin should be covered again with the mulching materials.

Shading

Shade has to be provided for the newly planted seedlings, if not already provided.

Management of pests and diseases

As the dry hot summer continued in this month, the pest population is all on the rise especially the weather sensitive pests such as black headed caterpillar, rugose spiralling whitefly and nesting whiteflies. Moisture deficit, diminishing relative humidity and rise in temperature favours the outbreak of these aforesaid pests. Coconut palm needs continuous moisture and nutrition for sustaining production and withstanding pressure from pest outbreak. Once the month accelerates population build up of pest coupled with moisture deficit situation would lead to palm ill health thereby reducing yield. Sustenance of palm itself would become very difficult under reduced humidity and rise in temperature. Nut setting gets reduced and palm health would divert for mere survival mechanism than for enhancing yield. Henceforth, the strategies outlined under soil and water management would turn more crucial in the general upkeep of palm health. Palm health management is therefore very crucial for the bio-suppression of black headed caterpillar and rugose spiralling whitefly.

Black headed caterpillar, *Opisina arenosella*

The coconut black headed caterpillar, *Opisina arenosella*, is a major pest prevalent in almost all coconut growing tracts across the country especially along the water bodies during winter. The infested portions get dried and form conspicuous grey patches on the upper surface of the lower fronds. Severe pest damage results in complete drying of middle to inner whorl of fronds leaving a burnt appearance. Presence of black headed caterpillars, webbing of leaflets and occurrence of dried faecal matter on the leaflets are the characteristic features of pest incidence. In the absence of natural enemies in the new area of emergence, the outbreak becomes faster and expands at high speed. Damage results in tremendous reduction in photosynthetic area, decline in rate of production of spikes, increased premature nut fall and retarded growth. Extensive feeding of caterpillars causes a crop loss of 45.4%

Pest infested field

Black headed caterpillar

Goniozus nephantidis

in terms of nut yield in addition to rendering the fronds unsuitable for thatching and other purposes. Farmers need not panic and this approach is one of the classical examples of successful augmentative biological control suppressed by natural enemies.

▶ Management

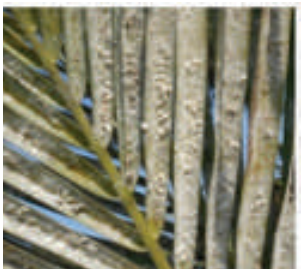
- Regular monitoring of palm fronds for pest occurrence in endemic zones.
- Removal and destruction of 2-3 older and dried leaves harbouring various stages of the pest. The leaflets could be burnt to reduce the caterpillar/ pupal population.
- Domestic quarantine should be strengthened by not transporting coconut fronds from pest-infested zone to pest free zone.
- Augmentative release of the larval parasitoids viz., *Goniozus nephantidis* (20 parasitoids per palm) and Bracon brevicornis(30 parasitoids per palm) if the pest stages is at third-instar larvae and above. The pre-pupal parasitoid (*Elasmus nephantidis*) and pupal parasitoid (*Brachymeria nosatoi*) are equally effective in pest suppression and are released at the rates of 49% and 32%, respectively for every 100 pre-pupae and pupae estimated.
- Before releasing, the parasitoids are adequately fed with honey and exposed to host odours (gallery volatiles) for enhancing host searching ability.
- Ensure adequate irrigation and recommended application of nutrients for improvement of palm health.

Rugose Spiralling Whitefly *(Aleurodicus rugioperculatus)*

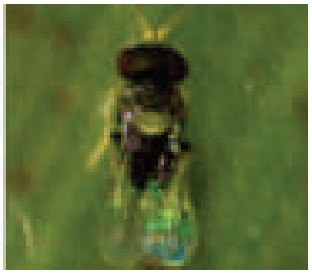
This period could also witness the establishment of the invasive rugose spiralling whitefly (*Aleurodicus rugioperculatus*) in new areas as well as re-emergence in already reported areas. Presence of whitefly colonies on the lower surface of palm leaflets and appearance of black coloured sooty mould deposits on the upper surface of palm leaflets are characteristic visual symptoms of pest attack. In severe cases, advancement in senescence and drying of old leaflets was observed. Leaflets, petioles and nuts were also attacked by the whitefly pest and a wide array of host plants including banana, bird of paradise, Heliconia sp. were also reported.

▶ Management

- In juvenile palms, spraying of water with jet speed could dislodge the whitefly and reduce the feeding as well as breeding potential of the pest.



Rugose spiralling whitefly Parasitized pupae



Encarsia guadeloupae

Sooty mould scavenger beetle

- Ensure good nutrition and adequate watering to improve the health of juvenile and adult palms
- No insecticide should be used as this causes resurgence of the pest and complete kill of the natural aphelinid parasitoid, *Encarsia guadeloupae.* A pesticide holiday approach is advocated for the build up of the parasitoid.
- Installation of yellow sticky traps and conservatory biological control using *E. guadeloupae* could reduce the pest incidence by 70% and enhance parasitism by 80%.
- Habitat preservation of the sooty mould scavenger beetle, *Leiochrinus nilgirianus* could eat away all the sooty moulds deposited on palm leaflets and cleanse them reviving the photosynthetic efficiency of palms.
- A close scrutiny should be made for the presence of other whiteflies including the nesting whiteflies on coconut system.

Nesting whiteflies (Paraleyrodes bondari and Paraleyrodes minei)

In addition to the rugose spiralling whitefly, two more nesting whiteflies (*Paraleyrodes bondari and Paraleyrodes minei*) are found associated with palm leaflets. Nesting whiteflies are smaller in size (1.1 mm) than rugose spiralling whitefly (2.5 mm). The nymphs are flatter with fibreglass like strands emerging form dorsum whereas the nymphs of rugose spiralling whitefly are convex in shape. Adult

P. bondari

P minei

Cybocephalus sp.

nesting whiteflies construct bird's nest like brooding chamber and sustains in the chamber. *P. bondari* had X-shaped oblique black marking on wings with two minute projections on rod shaped male genitalia whereas *P.minei* is devoid of black markings on wings and possesses cock-head like genitalia.

▶ Management

- In juvenile palms, spraying of water with jet speed could dislodge the whitefly and reduce the feeding as well as breeding potential of the pest.
- Ensure good nutrition and adequate watering to improve the health of juvenile and adult palms
- Effective nitidulid predators belonging to *Cybocephalus sp.* were observed on the palm system and pesticide holiday is advised for conservation biological control.

Disease

Leaf blight of coconut *(Lasiodiplodia theobromae)*

Leaf blight is an emerging disease in Coimbatore, Erode, Dindigul, Tirunelveli and Kanyakumari districts of Tamil Nadu. The pathogen causes damage in leaf and nuts. Affected leaflets start drying from the tip downwards and exhibit a charred or burnt appearance. The leaves in lower 3 to 4 whorls are affected. Leaf blight causes apical necrosis of lower leaves with an inverted "V" shape, and symptoms similar to those induced by drought (water deficit) and other stresses. The leaflets have extensive necrotic lesions with defined edges and without transition areas between the necrotic and healthy tissues. The pathogen can internally colonize the rachis, inducing internal necrosis that moves upward towards the stem (systemic invasion). The necrotic tissues develop exposed cracks that release gums under the leaf rachis and at petiole insertion. On coconuts, small black sunken region appear near the perianth of immature nuts.When nearly mature /mature nuts were infected, the infection spread internally into mesocarp without any external symptoms. The affected nuts are desiccated, shrunk, deformed and drop prematurely causing 10% to 25 % loss in nut yield.

▶ Management

- Improving the palm health by application of 5 kg neem cake enriched with Trichoderma harzianum and soil test based nutrition.
- Adequate irrigation and adoption of soil and water conservation measures is advised.
- Root feeding of hexaconazole @ 2% (100 ml solution per palm) thrice a year.

The dynamics of insect pests and diseases in coconut system vis-à-vis weather change pattern is so critical in population build up. Timely prophylactic measures to safeguard palms and enhancing palm health through need-based nutrition is very essential to withstand the pressure exerted by pests and diseases in outbreak situation. ■

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Market Review – February 2023

Domestic Price

Coconut Oil

During the month of February 2023, the price of coconut oil opened at Rs. 13700 per quintal at Kochi and Alappuzha market and Rs. 15300 per quintal at Kozhikode market. During the month, the price of coconut oil at Kochi and Alappuzha was almost steady during the month.

The prices of coconut oil closed at Rs. 13700 per quintal at Kochi and Alappuzha market and Rs. 14800 per quintal at Kozhikode market with a net loss of Rs. 500 per quintal at Kozhikode market.

During the month, the price of coconut oil at Kangayam market opened at Rs. 11667 per quintal and closed at Rs. 11333 per quintal with a net loss of Rs. 334 per quintal.

Weekly price of coconut oil at major markets Rs/Quintal)				
	Kochi	Alappuzha	Kozhikode	Kangayam
01.02.2023	13700	13700	15300	11667
04.02.2023	13700	13700	15300	11600
11.02.2023	13700	13700	15000	11533
18.02.2023	13700	13700	15000	11333
25.02.2023	13700	13700	14900	11333
28.02.2023	13700	13700	14800	11333

Milling copra

During the month, the price of milling copra opened at Rs.8600 per quintal at Kochi and Rs.8550 per quintal at Alappuzha and Rs.8900 per quintal at Kozhikode market. During the month, the price of milling copra at Kochi and Alappuzha was almost steady during the month.

The prices of milling copra closed at Rs. 8600 per quintal at Kochi market, Rs. 8550 per quintal at Alappuzha market and Rs. 8600 per quintal at Kozhikode market with a net loss of Rs.300 at Kozhikode market and it shows a downward trend during the month.

During the month, the price of milling copra at Kangayam market opened at Rs.8100 per quintal and closed at Rs. 8000 per quintal with a net loss of Rs. 100 per quintal.

**NR-Not reported*

Weekly price of Milling Copra at major markets (Rs/Quintal)				
	Kochi	Alappuzha	Kozhikode	Kangayam
01.02.2023	8600	8550	8900	8100
04.02.2023	8600	8550	8850	8100
11.02.2023	8600	8550	8750	8100
18.02.2023	8600	8550	8700	8000
25.02.2023	8600	8550	8650	8000
28.02.2023	8600	8550	8600	8000

Edible copra

During the month the price of Rajpur copra at Kozhikode market which opened at Rs. 10900 per quintal expressed a downward trend during the month and closed at Rs. 9800 per quintal with a net loss of Rs. 1100 per quintal.

Weekly price of edible copra at Kozhikode market (Rs/Quintal)	
01.02.2023	10900
04.02.2023	10600
11.02.2023	10200
18.02.2023	10350
25.02.2023	10000
28.02.2023	9800

Ball copra

The price of ball copra at Tiptur market opened at Rs. 11000 per quintal and closed at Rs.9600 per quintal with a net loss of Rs.1400 per quintal.

Weekly price of Ball copra at major markets in Karnataka (Rs/Quintal) (Sorce: Krishimarata vahini)	
01.02.2023	11000
04.02.2023	11000
11.02.2023	10300
18.02.2023	10500
25.02.2023	9800
28.02.2023	9600

Dry coconut

At Kozhikode market, the price of dry coconut opened at Rs. 10300 per quintal and closed at the same price.

Weekly price of Dry Coconut at Kozhikode market (Rs/Quintal)	
01.02.2023	10300
04.02.2023	10300
11.02.2023	10300
18.02.2023	10300
25.02.2023	10300
28.02.2023	10300

Coconut

At Nedumangad market in Kerala, the price of coconut opened at Rs. 16000 per thousand nuts and and the price was almost steady during the month.

At Pollachi market in Tamilnadu, the price of coconut opened Rs. 25000 per ton and closed at Rs. 23500 per ton with a net loss of Rs.1500 during the month.

At Bangalore market in Karnataka, the price of coconut opened at Rs. 20000 per thousand nuts and the price was almost steady during the month.

At Mangalore market in Karnataka, the price of coconut opened Rs. 26000 per ton and closed at the same price during the month.

Weekly price of coconut at major markets				
	Nedumangad (Rs./1000 coconuts)#	Pollachi (Rs./MT) ##	Bangalore Grade-1 coconut,(Rs./ 1000 coconuts) ##	Mangalore Black coconut (1 tonne) ##
01.02.2023	16000	25000	20000	26000
04.02.2023	16000	25000	20000	26000
11.02.2023	16000	25000	20000	26000
18.02.2023	16000	24000	20000	26000
25.02.2023	16000	23500	20000	26000
28.02.2023	16000	23500	20000	26000

International price

Coconut

International price and domestic price of coconut oil at different international/ domestic markets are given below.

Weekly price of dehusked coconut with water				
Date	Domestic Price (US$/MT)			
	Philippines	Indonesia	Srilanka	India*
04.02.2023	136	154	208	302
11.02.2023	135	152	203	302
18.02.2023	135	151	223	290
25.02.2023	135	151	235	284
				*Pollachi market

Coconut Oil

International price and domestic price of coconut oil at different international/ domestic markets are given below.

Weekly price of coconut oil in major coconut oil producing countries					
	International Price(US$/MT)	Domestic Price(US$/MT)			
	Philippines/ Indonesia (CIF Europe)	Philippines	Indonesia	Sri lanka	India*
04.02.2023	1098	1155	NR	2024	1403
11.02.2023	1113	1121	NR	1934	1395
18.02.2023	1100	1106	NR	2000	1371
25.02.2023	1119	1109	NR	2110	1371
					*Kangayam

Copra

The price of copra quoted at different domestic markets in Philippines, Srilanka, Indonesia, and India are given below.

Weekly International price of copra in major copra producing countries				
Date	Domestic Price (US$/MT)			
	Philippines	Indonesia	Srilanka	India* * Kangayam
04.02.2023	635	586	1119	980
11.02.2023	630	583	1091	980
18.02.2023	626	590	1160	968
25.02.2023	630	595	1303	968
				* Kangayam

#(Source: Epaper,Kerala Kaumudi), ##(Source: Star market bulletin)

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