Vol.LXVI No. 02 August- 2023 Pages-40 Price: Rs.6

Indian Coconut Journal

Polybag nursery for production of quality coconut seedlings

Circular Agriculture in Coconut

INDIAN
COCONUT
JOURNAL
Vol. LXVI No.02
August - 2023
Kochi - 11

Publisher
COCONUT DEVELOPMENT BOARD
Ministry of Agriculture and Farmer's Welfare,
Department of Agriculture, Government of India
Kera Bhavan, Kochi - 682 011, India

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SUBSCRIPTION

Annual	Rs. 60.00
Single Copy	Rs. 6.00
Institutes / Libraries	
Annual	Rs. 200.00
Single Copy	Rs. 20.00

Articles, research papers and letters on different aspects of coconut cultivation and industry are invited for publication in this Journal. All accepted material will be paid for. The Board does not accept responsibility for views expressed by contributors in this Journal. All remittances and correspondence should be addressed to the Chairman, Coconut Development Board, Kochi - 682 011.

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 six State Centres situated in the states of Orissa, West Bengal, Maharashtra, Andhra Pradesh, Gujrat 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

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Dear Readers,

World Coconut Day – A day to celebrate this Wonder Crop, in unison, by coconut lovers across the world

This auspicious day for the Kalpavriksha falls on 2nd of September every year. The day is celebrated by the diverse stakeholders in the sector starting from farmers, farmer producer organisations, processors, entrepreneurs, exporters, researchers, scientists, development officers, consumers and the list goes on. World Coconut Day is celebrated across the globe in commemoration of the foundation year of International Coconut Community (formerly known as Asian and Pacific Coconut Community) in 1969. The theme for World Coconut Day 2023 is "Sustaining Coconut Sector for the Present and Future Generation" in line with the definition of Sustainable Development.

Countries celebrate the day with programmes, seminars, coconut festivals and related events to promote the goodness of coconut. The continued focus during World Coconut Day celebrations is focus on innovations and technology to make the sector vibrant and take the goodness and usefulness of coconut to the millions of consumers of coconut products. The sector is to emerge viable and profitable taking the benefits to the millions of stakeholders thus contributing to their welfare and prosperity.

In India, the national level celebrations of World Coconut Day on 2nd September 2023 will be organised at Gwalior in Madhya Pradesh. The event will be inaugurated by the Hon Union Minister for Agriculture and Farmers Welfare, Shri. Narendra Singh Tomarji. The Board is also celebrating the day in collaboration with ICAR CPCRI at its campus in Kasaragod which will be inaugurated by the Hon. Minister of State for Agriculture and Farmers Welfare, Sushri. Shobha Karandlajeji. World Coconut Day will also be celebrated by the Board in the major coconut growing states by the Regional Offices, State Centres and the Demonstration cum Seed Production Farms of the Board.

The objective of the World Coconut Day celebrations in different parts of the country is to popularise coconut cultivation and coconut consumption inwards to newer areas. Coconut is an essential part of our culture and tradition and is the most auspicious item in every ritual and religious offering. Apart from that, celebration of the day in new parts of the country will take the goodness of coconut to newer populations and societies, creating new niche markets in some areas while expanding existing ones in other areas.

Major coconut producing countries like Indonesia and the Philippines are also celebrating the event. In Indonesia, the International Coconut Community in collaboration with the Gorontalo Regency and Dekindo are organising a Coconut Festival during 21-25 September 2023 at Gorontalo in North Sulawesi. The United Coconut Association of the Philippines, the trade body of coconut industry players are organising the World Coconut Congress and Exhibition during August 30 to September 1, 2023 at the World Trade Centre, Metro Manila, Philippines.

Let us celebrate and spread the goodness of coconut – to move towards food security, nutritional security, social security and economic development.

Editor

Polybag nursery for production of quality coconut seedlings

M. Shareefa, Mayalekshmi, S. Indhuja and Regi J. Thomas
ICAR-CPCRI, Regional Station, Kayamkulam

Quality planting material is an important component for enhancing the production and productivity of any crop. It has more relevance in coconut because of long juvenile period lasting for four to six years and an economic life span of more than 60 years. Seedling vigour is correlated with adult palm characteristics such as early flowering, high nut yield and copra production. Scientific nursery management practices are essential for production of quality planting materials. Conventionally coconut seedlings are raised in a nursery prior to field planting as proper care and maintenance of a seedbed facilitates the selection of early germinating vigorous seedlings. The most common method of production of seedlings in coconut is to sow the nuts in nursery beds and allow them to grow there itself for atleast one year till they are ready for transplanting in the main field.

Transplanting germinated seednuts in polybags filled with suitable potting mixture can also be practised to produce vigorous and quality seedlings. Raising coconut seedlings in polybags was introduced in 1969 in the Ivory Coast of West Africa. Although polybag nurseries are popular in other major coconut growing countries, it is not widely adopted in India. The use of polybag seedlings is becoming needful especially where the land is not favourable for planting coconut seedlings in certain period of time. In Kerala, the distribution of coconut seedlings by developmental agencies mostly happens during June-July and during that period low lying areas like Kuttanad are not conducive for planting coconut seedlings due to water logging. Under such circumstances, farmers can buy polybag coconut seedlings and planting can be done as and when the land is ready for planting.

Advantages of polybag nurseries

- Enables production of vigorous seedlings

Polybag nursery is preferred to conventional field nursery as intensive care and maintenance of individual seedlings result in vigorous seedlings with better root system, which results in early flowering

- Easy maintenance of seedlings

Compared to a nursery in the field, watering, weeding and culling operations for the elimination of unwanted seedlings are easier in polybag nursery.

• Reduces transplanting shock

Since the root system is intact and does not get damaged at the time of transplanting, the transplanting shock can be avoided. These seedlings on planting in the field will grow faster. Such seedlings can be used for gap filling to obtain a uniform stand and age group in the garden.

• Transplanting can be done at any time

This is one of the most important advantages because of the unpredictable climatic conditions. The polybags also facilitate, if required to prolong the nursery period until the environment is conducive for main field planting.

However, this technique has certain drawbacks such as high cost of transportation and involvement of additional labour for filling bags and extra costs for materials like polybags and potting mixture.

Technique of raising polybag nursery

Selection of site

Nursery must be located near a dependable water source to facilitate irrigation throughout the year. The site should have transportation facility, as otherwise considerable difficulty will be experienced both in the matter of bringing seed nuts to the nursery and sending the seedlings out. The land is to be weeded and levelled. About 25000 seedlings can be accommodated in an area of one hectare of nursery area at a spacing of 60 cm x 60 cm.

Sowing seednuts in pre –nursery

Generally seednuts are not sown directly in polybags. In order to produce poly bag seedlings, the seed nuts are initially sown at closer spcaing and allowed to germinate in pre-nursery bed. The seednuts start germinating about one to three months after sowing depending on variety. In conventional nursery, seednuts are sown in beds at spacing of 30 cm between rows and 25-30 cm within rows and remain there for about 12 months. For raising polybag seedlings, seednuts are sown vertically at a spacing of 5 cm and transplanted in polybags when the sprouts are 8-10 cm long. There should be more than 80% germination in 20 weeks under optimum management and seednuts that do not germinate by then are discarded.

Preparation of potting mixture and filling the bag

The seedlings can be raised in black polythene bags (500-gauge thickness) of 60 cm x 45 cm size for bigger nuts and 45 cm x 45 cm for smaller nuts. The bottom of the bags is to be provided with 8-10 holes for draining the excess water. To fill 100 bags, around 2.0-2.5 m^3 of potting mixture will be required. The commonly recommended potting media are top soil mixed with sand in 3:1 ratio or fertile top soil, sand and well decomposed and powdered cattle manure / vermicompost in the ratio of 3: 1: 1. Red earth, well decomposed and powdered cattle manure/ vermicompost and sand in 1: 1: 1 ratio can also be used.

Soil less media comprising of vermicompost and coir pith compost can also be used as potting mixture. The advantage is that besides being free of pests, nematodes and spores of fungi and other contaminants, this can be blended with additional ingredients for preferred drainage, water retention, nutrition, and airspace. A soilless mix is also lighter in weight than potting mixture containing soil. As an eco-friendly alternative, jute/gunny bags can also be used for filling potting mixture as it has bio degradable quality.

Transplanting to polybags

The germinated nuts are picked out from the nursery once in a week until 80% of nuts are germinated or up to five months from sowing whichever is earlier. The germinated nut is placed in the half filled bags with the sprout positioned upwards in the centre of the bag. Sufficient potting mixture is then added to fill the bags up to two-third portion and the sides slightly pressed to keep the nut firm to ensure that potting mixture is not lost during watering. Care must be taken not to plant pest or disease affected sprouted nuts and not to cover the collar of the young seedling while filling the bags.

Laying out of polybag nursery

The size and lay out of the land depend on the spacing of bags and irrigation system adopted. Spacing of bags mainly depends on the expected

duration the seedlings are to be kept in the nursery. Usually the polybag seedlings are maintained for about 8-10 months in the nursery. The size of the polybag nursery bed can be 6 m x 3 m with about 1 m in spacing between beds for facilitating hose irrigation and carrying out other cultural operations like weeding and manuring.

Maintenance of polybag nursery

Irrigation

Regular watering of the polybag nursery is very important to ensure proper growth of seedlings. The frequency of watering should be adjusted depending upon rainfall and other weather conditions, type of potting mixture used and age of seedling. Irrigation is to be given on alternate days during the summer months. Several irrigation systems are available and factors such as ease of use, size of nursery, capital investment etc. must be considered while selecting the irrigation system. While sprinkler irrigation is ideal for larger nurseries, hose irrigation is suited for smaller nurseries. However, care must be taken not to wash the medium out of the polybag during irrigation. If coir dust is used as a component of potting mixture, it can hold water for longer duration and hence irrigation may be done @ 1 litre / bag once in 4 to 5 days.

Weeding

Weeds adversely affect the growth of seedlings and therefore, it is essential that they are to be removed frequently. Since soil or sand is a component of potting medium, there is every chance of weeds growing in polybags. The surrounding area of the nursery also should be kept weed free by frequent weeding. Polybags can be placed on a sheet of black plastic to prevent weed growth and penetration of the root of the seedlings into the soil.

Manuring

The seed nut has considerable reserves of essential plant nutrients in it. However, the roots are capable of absorbing the nutrients one month after their initiation. Since the potting mixture made of fertile topsoil, cattle manure or vermicompost can provide the nutritional requirement of seedlings, it may not be necessary to add fertilizers. However, if growth of seedlings is not found satisfactory, fertilizers can be applied in the poly bags @ 20 g ammonium sulphate and 25 g muriate of potash per bag after two months of germination and 45 g of ammonium sulphate and 45 g of muriate of potash per bag after four months of germination. Seedlings are to be watered after application of fertilizers. The fertilizer is to be spread around the seedlings and forked into the medium.

Shading

Plant protection

Careful inspection of seedlings for incidence pests and diseases in the nursery and suitable plant protection measures must be taken as soon as symptoms are noticed.

Field planting of polybag seedlings

Vigorously growing seedlings of about 8 to 10 months old with early splitting of leaves having more than 10-12 cm collar girth can be selected for planting in the main field. The seedlings are to be sufficiently watered to ensure adequate moisture reserve in the bags on the day of transplanting. Polybag seedlings are to be handled carefully and the plants should not be held at the collar, which can unearth it. There is also scope for introduction of bio-inoculants like Kera Probio (Plant Growth Promoting Rhizobacteria) / Azospirillum (Nitrogen fixing bacteria) / phosphate solubilizers in polybags before field planting for better establishment of these beneficial microorganisms. If the roots have grown through the bag, they are to be cut before taking from the nursery. While planting, the sides of the polybag may be cut vertically along the sides with sharp blade/knife and planted along with the full potting mixture inside a big sized pit made in the main field.

Poly bag seedlings usually costs 30% higher than normal bare rooted seedlings as it involves cost of polybags, vermicompost, cocopeat etc and additional labour cost for preparing and filling potting mixture and manuring the seedlings. The high cost of polybag seedlings compared to normal seedling can be compensated by the vigorous seedlings with good root system and reduced transplanting shock that would result in quick field establishment and early flowering.

Reminiscence and Research Imprints of Aliyarnagar and Veppankulam AICRP (Palms) Centres

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Genesis

Coconut is an inevitable horticultural crop of the state of Tamil Nadu, spreading across 4.36 lakh hectares, paying rich dividends to the state economy in terms of employment opportunities and export potential. However coconut is, indeed a sensitive victim to the catastrophes of biotic and abiotic stresses. To address the research needs of the coconut growers of the state in terms of development of new varieties, cutting edge production technologies to scale-up on farm productivity and to circumvent pest and disease incidence, under the aegis of ICAR-All India Co-ordinated Research Project on Palms, Veppankulam Centre was established in the Eastern zone and Aliyarnagar Centre in the Western Zone of the southern most state of the nation during 1973 and 1988 respectively. These two centres form potential research zones of Tamil Nadu Agricultural University, Coimbatore in addressing coconut borne research needs of the state.

Physiographic and Edaphic Overview

Aliyarnagar Centre is located near Western Ghats (100 N, 770 E longitude), 20 kms south of Pollachi city (Coconut city) at an elevation of 260 m above

3. TNAU ALR (CN) 2

MSL with an average annual rainfall of 802 mm. The centre is established in 22 hectares of land, of which 18.8 ha is under cultivation. The soil type is sandy clay loam (Typic / Fluventic Ustropept) belonging to Aliyar series. Veppankulam centre is located in Pattukkottai block of Thanjavur district (Granary of Tamil Nadu) spreading across 33.18 ha of which, 25.6 ha is under cultivation, with sandy loam soil. The mean maximum and minimum temperatures are 38.50˚C and 26.00˚C respectively. The mean annual

Coconut Research Station Aliyarnagar

Coconut Research Station, Veppankulam

rainfall of Veppankulam centre is 1120 mm and the centre is always under the threat of thwarting cyclonic storms.

Crop Breeding

Veppankulam Centre holds the pride of releasing the World's first coconut hybrid VHC 1 (ECT x MGD) during 1982 with a yield potential of 115 nuts per palm per year and it is the landmark of coconut breeding in the state of Tamil Nadu. Encouraged by the superior performance of this T x D hybrid and their reciprocal combinations, different inter and intra varietal crosses involving promising exotic and indigenous varieties were made viz., Tall x Tall, Tall x Dwarf, Dwarf x Tall and Dwarf x Dwarf and subsequently two other T x D hybrids viz., VHC 2 (ECT

Salient Features of the varieties released by the centres

S. No	Variety/ hybrid	Parentage	Year of release	Annual nut yield/ palm	Special feature
1.	v ALR (CN)1	Selection from Arasampatti Tall	2002	126	48 %, 88 % and 66 % yield increase over WCT, ECT and VPM 3 respectively • 300 ml of tender nut water • 16.5 kg copra / palm / year
2	ALR (CN)2	Selection from Tiptur Tall	2010	109	Copra content – 136 g/nut • Copra yield - 14 kg /palm / year • Oil content – 64.7% • Drought tolerant
3	ALR (CN)3	Selection from Kenthali Dwarf	2012	86	500 ml of tender nut water • Total soluble sugars – 5.2% • Rich in potassium – 190.2 mg per 100 g. • Tolerant to Eriophid mite
4	VHC 1	East Coast Tall x Malayan Green Dwarf	1982	115	Medium tall with moderately thick trunk, Oblong nuts • Circular crown • 40 months for first flowering, • Oil content 68.6%
5	VHC 2	East Coast Tall x Malayan Yellow Dwarf	1988	142	• Medium tall, Thick trunk • Semi circular to circular crown • 43 months for first flowering • Medium to big oblong nuts • Oil content 70.2% • Copra content 146 g/nut
6	VPM 3	Selection from Andaman Ordinary Tall	1994	92	• Tall, Circular crown, thick trunk • 63 months for first flowering • Big oblong nuts • Oil content 70% • Copra content 176g/nut • Drought tolerant
7	VHC 3	East Coast tall x Malayan Orange Dwarf	2000	156	• Medium tall, Thick trunk • Semicircular to circular crown • 46 months for first flowering • Medium to big oblong nuts • Oil content 70.2% •Copra content 162 g/nut.
8	VHC4	Laccadive Ordinary Tall x Cochin China	2015	166	• Early flowering 3 ¾ years • Moderately tolerant to drought • First T x T hybrid in the country as well as in South Asia

ALR (CN) 1

P8-Intercropping in coconut management

x MYD) with 147 nuts and VHC 3 (ECT x MOD) with 156 nuts per palm per year were released during 1988 and 2000 respectively. VPM 3, a selection from Andaman Ordinary Tall during 1994 and VHC 4 (Laccadive Ordinary Tall x Cochin China Tall) during 2015 were released for cultivation. ICAR-Central Plantation Crops Research Institute, Kasaragod has a long standing relationship with Coconut Research Station, Veppankulam since 1959 in exchanging both exotic and indigenous germplasm accessions. At present the centre is maintaining a total assemblage of 53 germplasm consisting of 29 indigenous and 24 exotic collections. Forty genotypes were screened and the volume of tender nut water was found to be higher in San Ramon (Tall) and Gangabondam Dwarf varieties. At present, a total of 79 hybrids comprising of 27 Tall x Tall, 19 Tall x Dwarf, 19 Dwarf x Tall, 6 Dwarf x Dwarf one double cross and 7 three way cross hybrids are under various stages of evaluation.

ALR (CN)1 with yield potential of 126 nuts, a selection from Arasampatti Tall and ALR(CN)2, selection from Tiptur Tall with an annual nut yield of 109 nuts, both of which incorporates drought tolerant nature were released by Aliyarnagar centre during 2002 and 2010 respectively. Orange husked dwarf variety tolerant to eriophid mite ALR (CN)3 was released during 2012. In collaboration with ICAR-CPCRI, handful of varieties viz., Kalpa Surya, selection from Malayan Orange Dwarf, Kalpa Prathiba, Kalpa Shatabdi accolade as 'Family pack of Tender nut water' and Kalpa Ratna, a selection from Federated Malay States Tall were evaluated at Aliyarnagar centre and released for commercial cultivation. Five Tall x Tall cross combinations are presently evaluated for yield potential and quality traits.

Crop Production

An array of crop production technologies was developed by both the centres to scale up on-farm productivity, profitability together with sustained use of natural resources. Multispecies cropping

21. VHC 1

P8-Intercropping in coconut management

Gomphrena in coconut at Aliyarnagar

Celosia in coconut at Aliyarnagar

system model accommodating black pepper, banana, elephant foot yam and coriander in coconut for Eastern Zone of Tamil Nadu has penetrated deep in the farmers' holdings for fetching higher profitability. Similarly high intensity synergistic cropping system model with coconut, banana, cocoa, pineapple and pepper has been standardized for Western Zone of Tamil Nadu by Aliyarnagar Centre and is widely adopted by the farmers.

Befitting intercrops in coconut

In the research conducted at both the centres, Sitharathai *(Alpinia galanga)*, Siriyanangai (*Andrographis paniculata*), Karisalanganni (*Eclipta prostrata*), Katralai (Aloe vera), Tulsi (*Ocimum sanctum*), Lemon grass (*Cympobogon sp*.) and Patchouli (*Pogostemon cablin*) were identified as the remunerative medicinal intercrops for coconut. Five flower crops viz., Chrysanthemum (*Dendranthema grandiflora*), Celosia (*Celosia sp*.), Marigold (*Tagetes erecta*), Zinnia (*Zinnia sp*.) and Gomphrena (*Gomphrena globosa*) were evaluated for their intercropping potential in coconut garden of which marigold and gomphrena were identified as the harmonious floral intercrops, which helps the farmers in fetching additional income during the festival seasons.

Water Management Research

Both the centres of Tamil Nadu have made rapid strides in water management research. Based on pan evaporation and crop water requirement, basin irrigation at IW / CPE ratio of 1.0 with 4 cm depth of water and drip irrigation at 100 % Eo and 66 % Eo resulted in a nut yield of 146, 149 and 129 nuts per palm per year respectively in VHC 2 variety of coconut as against 86 nuts per palm per year in life saving irrigation. Spreading 150 -200 husks in convex position or 15 numbers of dried coconut fronds or 30 kg of coir pith in the palm basin is recommended as a cost effective moisture conservation strategy which is widely adopted by the farmers.

Irrigation water requirement has been standardized for Eastern and Western Zones of Tamil Nadu for normal, moderately water scarce and drought conditions both under drip and basin irrigation, which is incorporated in the Crop Production Guide of TNAU and is used as a standard reference for water management in the state.

Irrigation water requirement for diverse water availability conditions

Months	Quantity of water to be applied (lit/day)		
	Adequate water available area	Moderate water available area	High water scarcity area
Through drip irrigation:			
Feb - May	65	45	22
Jan, Aug and Sep	55	35	18
June, July, Oct -Dec	45	30	15

Integrated Plant Nutrition Supply

Coconut is a perennial crop exploring nutrients from a limited volume of soil and exporting nutrients out of the farms in terms of its residues. An array of technologies was developed by both the centres towards enrichment of soil fertility in coconut plantations. Sowing of sunhemp @ 100 g/palm or 40 kg /ha and incorporating, recycling of organic wastes through vermicomposting and biocomposting techniques, effective utilization of coirpith by enriching with rock phosphate and biofertilizers find wide adoption at farm level towards soil health enhancement.

Macronutrient (NPK) requirement of an adult coconut was arrived as 560-320-1200 g per per palm per year which helps the farmers in tailoring fertilizer application. Site Specific Nutrient Management with secondary and micronutrients together with biofertilizers for enhanced productivity by 32 % over farmers' practice in Tender nut variety has been developed by Aliyarnagar centre and disseminated to the dwarf coconut growers. A milestone moment of Veppankulam centre is the formulation of Coconut Tonic loaded with micronutrients and growth regulators, recommended @ 200 ml per palm through root feeding once in every six months, has received wide reception at the farm front because of its witnessing potential to control button shedding. Equally TNAU micronutrient mixture developed based on the research undertaken in both the centres serves as a remedy for micronutrient related maladies especially Pencil Point Disorder in coconut. Spraying of growth regulators for the control of button shedding and barren nut production in coconut has also been developed.

Crop Protection

Thanjavur region identified as an endemic zone for deadly Basal Stem Rot (BSR) disease or Thanjavur wilt (*Ganoderma lucidum*) after coastal cyclones of 1952 and 1955, was the stimulus behind establishment of Veppankulam Centre. Root feeding of hexaconazole @ 3 ml in 100 ml water combined with soil drenching of 40 litres of 1 % Boradeaux mixture thrice at quarterly intervals was promulgated to control the disease. In a similar fashion, Integrated Disease Management modules were developed for the other dreadful diseases viz., leaf blight and bud rot. Kerala wilt of coconut is the major instigation towards genesis of Aliyarnagar Centre. Intense surveys are conducted to document the micro-meterological parameters towards the occurrence of the disease and an alloy of approaches comprising of nutrient management, intercultivation and microbial consortia has been developed to contain the disease. The centres have also made rigorous efforts to control post harvest diseases of coconut. To cite a few, potassium metabisulphite and benzoic acid for the control of Aspergillus flavus in copra.

To curb the menace of debilitating pests, integrated approaches were developed and validated by both the centres. Placement of naphthalene balls in the innermost whorls, crown application of neem seed kernel powder and sand, leaf axil application of phorate granules or carbofuran, fixing Rhinolure @ one per ha with natural attractants are developed as the approaches towards management of rhinoceros beetle. Placement of ferrolure @ one per ha for the management of the 'killer pest 'Red palm weevil, spraying of Triazophos and root feeding of 1 % azadirachtin @ 10 ml for the control of eriophid mite, are few of the noteworthy technologies developed by both the centres. Incidence of a new invasive Rugose spiraling whitefly (RSW) *Aleurodicus rugioperculatus Martin* was first recorded in coconut during August 2016, in Anaimalai block of Coimbatore Dt., Tamil Nadu. Natural parasitism by *Encarsia guadeloupae* was observed in the same block, subsequently leading to biosuppression of RSW. Technology capsule comprising of traps, predator *Chrysoperla zastrowi*, nymphal parasitoid, *Encarsia gudaloupae* and forcible water spray to suppress the pest has been developed.

Spraying of Azadirachtin TS 1% followed by release of two larval parasitoids Braconids, Bethylids and pupal parasitoid Chalcid registered significant reduction of *Opisina arenosella* population. Aliyarnagar centre is the only production site for continuous supply of larval parasitiod Bracon brevicornis for the management of black headed caterpillar in the state.

Social Impact

Besides technological interventions, the centres also radiate social commitment. COVID -19 has left special imprints in the rural economy of the nation especially in coconut farming. Reverse migration of workers who could not be absorbed per se in

farm holdings, disruption of distribution channels, curfew stagnation of harvested coconut, shattered business cycles and informal economy inched up rural unemployment during the pandemic. In the backdrop of the dreadful scenario, goat farming has turned out to be a viable endeavor and a pivot of confidence for rural unemployed youth towards economic prosperity, emotional well being and to transform them as a profitable entrepreneur and no doubt, it is the Integrated Farming System models located at both the centres behind painting a silver streak in the gloom of the lives of rural unemployed in the Eastern and Western agro climatic zones of the state.

Both the centres are actively involved in taking path breaking research technologies to the door steps of the farmers through series of trainings, seminars and awareness campaigns. Field demonstrations are being conducted to showcase viable research technologies in farmers' holdings. Under SCSP / TSP mission, hundreds of technologically deprived farmers are trained on improved coconut production technologies and agro inputs associated with coconut farming are distributed to them by both the centres. Diagnostic field visits are made by the scientists to resolve emerging issues in the palm sector. Linkages have been developed with Krishi Vigyan Kendras and Farmers' Producers Organizations to foster cluster approach for channelising coconut trade. Handful of publications as books, technical bulletins, research articles, pamphlets and folders are being published by the scientists to enhance the visibility of the centres and to benefit the farming community.

Both Aliyarnagar and Veppankulam centres marches with the goal of developing path breaking technologies coated with societal commitment. The vision of ICAR – AICRP (Palms) located in Tamil Nadu Agricultural University, Tamil Nadu is to take the glory of coconut farming to unsurpassed heights in future and the mission continues.

Retirement

Shri Hemachandra, Director retired from the services of Coconut Development Board on 30th July 2023 after serving the Board for more than 35 years.

Indcarb Activated Carbon Private Limited inaugurated it's Corporate Office

Indcarb Activated Carbon Private Limited, manufacturer of coconut shell based activated carbon with its latest state of the art plant situated in the industrial area in Kanjikode, Palakkad District, Kerala formally inaugurated its corporate office on 27th July 2023. Smt. Deepthi Nair S, Director (Marketing) Coconut Development Board inaugurated the corporate office in the presence of officials from various government departments and financial institutions.

The company which started its commercial production in March 2021 is one of the modern, automated activated carbon plants in India. M/s.Indcarb also announced its future plan for expansion with value added activated carbon products during the occasion.

Recently the company was awarded the best manufacturing startup unit by Kanjikode Industies Forum (KIF). The unit is ISO certified and is a One Star Export House.

Development of moisture content-based kiln drying schedule of high-density coconut palm wood used for flooring

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Abstract

Coconut (*Cocos nucifera L.*)-based farming systems in Kerala offer a variety of ecosystem services, including provisioning services such as the use of coconut wood as a construction material. The renewability and abundance of coconut wood can supplement the wood industry and aid in the conservation of natural forests by reducing their exploitation. The coconut palm tree is India's most important palm, yet less known as a flooring species. This study investigates the characteristics of drying defects and develops moisture content-based drying schedules of 25 mm and 50 mm thick high-density coconut palm wood for flooring. The drying schedules were developed using the method (quick drying test) proposed by Terazawa (1965). The schedule was then applied to coconut woods and evaluated. Boards with a thickness of 50 mm were dried at an initial temperature of 39°C, an initial relative humidity of 89%, an initial wet bulb depression of 2°C, and a final temperature of 57°C. Furthermore, 25 mm thick boards should be dried with a harder drying schedule with an initial temperature of 45°C, initial relative humidity of 90%, initial wet bulb depression temperature of 2°C, and final temperature of 62°C.

Keywords: Cocos nucifera L. Density Drying defect Quick-drying test Kiln-drying schedule

Introduction

Worldwide, wood consumption is growing steadily, but there is a significant gap between supply and demand for wood and wood products. Global wood production (fuelwood and industrial round wood put together) increased from 2.5 billion m^3 in 1961 to 4 billion m^3 in 2019 (FAOSTAT,2022). Researchers have forecast future supply and demand for forest products based on historical trends and plausible future development scenarios. According to Johnston and Radeloff(2019), global round wood production will increase by 53% by 2065 compared to 2015, and sawn wood production will reach a maximum of 606 million m^3 by 2065. Wood production systems will face increasing pressure in the bio-economy context due to multiple biomass demands for energy and material uses (*Verkerk et al.,*2021). However, certain factors can cause these trends to shift or reverse. Factors could include increased wood productivity, using product streams rather than round wood, improved recycling of wood products (*Hetemakiet al.*,2020) and using lesser-known species. The effective utilization of wood in coconut palm stems is gaining prominence in the current scenario, which aids in meeting domestic wood demand and bridging the supply-demand gap for wood.

Coconut palm tree is an important perennial multipurpose crop distributed in 93 countries (Saha and Mat, 2018). In India, the coconut palm tree is found in hot and humid regions (*Swathi et al.*,2021). It is grown on nearly 2.2 million hectares (APCC,2019). Kerala accounts for a major share of the area in India. The coconut area in Kerala is increasing at a compound growth rate of 0.62 % per year (CDB, 2022).

CBFS represent a notable agroforestry system in the Indian state of Kerala. These systems are known to provide diverse ecosystem services that can be broadly categorized into regulating, supporting, provisioning, and cultural services. Among the provisioning ecosystem services, the potential use of coconut wood as a structural material deserves further exploration. Coconut wood can serve as a valuable supplement to the raw materials used in the wood industry, offering low-cost and durable construction materials. By virtue of its abundant availability and renewability, coconut wood can contribute to the sustainability of the construction

sector and alleviate the pressure on natural forests, thus promoting their conservation (Kumar and Kunhamu, 2022)

Coconut palm wood has many uses; generally, two-thirds of the stem height is widely used for structural applications. Some researchers have unveiled the potential of coconut palm wood for flooring by testing different physico-mechanical properties (Mohmod and Tahir, 1990; *Fathi et al.*,2014; *Bailleres et al.*,2010). The internal MC of the wood flooring material and the prevailing conditions are important factors in determining its durability. Apart from required physical properties, defect-free and resilient to climate variables and force (mechanical properties) are the essential quality parameters of wooden flooring materials.

The raw materials for wooden flooring must be properly dried according to the required standard. Wood drying is a complex system of interference processes and is an inevitable stage in the wood product manufacturing line. Conventional and kiln drying approaches control the appropriate moisture content, quality, and cost of production. However, air drying is a tedious process and is highly susceptible to drying defects and biodeterioration. On the other hand, kiln drying with a suitable schedule is a reliable approach to producing defect-free wood material in a short period.

Optimizing kiln temperature, humidity, and air circulation are the industrial requirements for high quality, quick drying time, and low drying cost. Even so, it is a difficult task considering each species' unique characteristics. Various methods are available, such as TNIIMOD, Forest Products Research Laboratory-Princes Risborough, Forest Product Laboratory, Romanian standard (STAS 10349/1-87), and Truebswetter to establish wood drying schedules. Each method generates a drying schedule using a different algorithm. As a result, there are differences in the air temperature and relative humidity values proposed by various methods. When the species name is found in the table, the above methods are simple, quick, and reliable for industrial use. When a wood species is not found in the table, laboratory research is required to determine the critical drying conditions of the wood species under consideration (Bedelean, 2017). This study aims to develop moisture content-based kiln schedules of 25 mm and 50 mm thick coconut palm wood for flooring.

2 Materials and Methods

2.1 Collection, Conversion, and Sampling

A mature west coast tall coconut tree of 11 m height was collected from Thrissur district, Kerala, India, and cross-cut into 3 metres billets. The basal log portion was converted to flat-sawn boards with the help of a portable band saw. Planed high-density flat-sawn boards with 25mm and 50mm thicknesses were selected for sampling.

Samples were cut from flat-sawn boards for the quick drying test (QDT) and physical property measurements (Fig. 1). Twenty samples were used for QDT in two different thicknesses (ten samples of 25 mm thickness and ten samples of 50 mm thickness), which were 200 mm x 100 mm in length and width. The QDT of 25 mm thick and 50 mm thick samples were conducted separately.

The MC was measured using thirty samples (15 from each thickness) of size 25 mm x 20 mm x 20 mm, and the density was calculated using thirty samples (15 from each thickness) of size 60 mm x 20 mm x 20 mm.

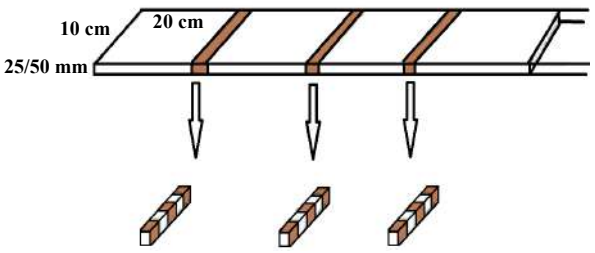

Fig. 1 Scheme of the test specimen collection from a plank

2.2 Physical properties

2.3 Moisture content (MC%)

The samples were weighed and dried in hot air oven at 103±2°C until constant weight was recorded. The MC was calculated from the weight loss using the following formula (1) (IS: 1708-1986).

Ww= Green weight of the sample

Wo= Dry weight of the sample

$$MC\% = \frac{W_w - W_o}{w0} \times 100 \quad \text{Eq}$$

2.4 Basic density (BDKg/m³)

The volume of samples was calculated using the water displacement method, which involved filling a container with water and placing it on a digital balance with a precision of 0.01 gm. The samples were oven-dried at 103±2°C until they reached a constant weight (Wo oven-dry weight) and kept in a desiccator with desiccant (Silica gel) to keep the samples dry. The samples were weighed immediately after removal from the desiccator, and the density was then calculated using the formula

$$BD(Kg/m^3) = \frac{\text{Dry mass}}{\text{Geen volume}} \quad \text{Eq. (2)}$$

2.5 QDT

QDT provides an easy means for determining kiln-drying control parameters (Initial Dry Bulb Temperature (IDBT), Initial Wet Bulb Depression (IWBD) and Final Dry Bulb Temperature (FDBT)). Samples were placed 75 mm apart, edgewise upright in a hot air oven at 103±2°C until they reached constant weight. The samples were taken from the oven every hour for the first 8 hours, the 24th and 30th hours (2nd day), and the 48th hours (3rd day) for weight measurement and drying defect evaluation. The purpose was to find the highest scoreof the end check and surface checks that appeared during the initial drying stage and of deformation and honeycombing that seemed severe at the end drying stage.

2.6 Evaluation of drying defects

Terazawa (1965) established a correlation between the initial drying conditions and the degree of drying defects called Terazawa's criteria. Checks and deformation were graded on a scale of 1 to 8, while honeycombing was graded on a scale of 1 to 6. These scales were used to evaluate the drying defect characters.The highest degree of defects was then compared with Terazawa's criteria to establish the initial drying conditions of schedules.The samples were subsequently given a corresponding score based on the classification. The defect score was allotted for each piece, based on severity and occurrence, as the method developed by Terazawa (1965) and cited by Jankowsky (1992), *Basri et al.* (2005), *Tan et al.* (2010), Ofori and Brentuo (2010), Effah(2014), and *Kumar et al.* (2018).

2.7 Evaluation of initial checks

Surface and end checks are the first set of defectsthat appearduring the early stage of drying, which is closely associated with relative humidity. The defect intensity was measured by giving scores based on the visual observations and size (length and width) of the defects based on Terazawa's criteria and modified by Jankowsky (1992).

2.8 Evaluation of internal checks (Honeycombing) and deformation

After QD, each sample was cut (perpendicular to the length) into approximately two-half to determine the degree of internal checks and deformation. The size and number of internal checks on the newly exposed surfaces were examinedand classified based on a predetermined internal checks classification set by Terazawa (1965).The two extreme ends at the cut edge for each half (newly exposed surface) were labelled 'X',and another point apart 1-2 cm from 'X"was labelled as 'Y'(Fig.2). The thickness was measured at points X and Y along the four edges of the two halves with a digital calliper. The thickness difference between the thickest and thinnest edges was computed for each of the four edges. The mean value was calculated for each sample's four differences (X-Y), and the degree of deformation was assigned using Terazawa's (1965) classification of deformation.

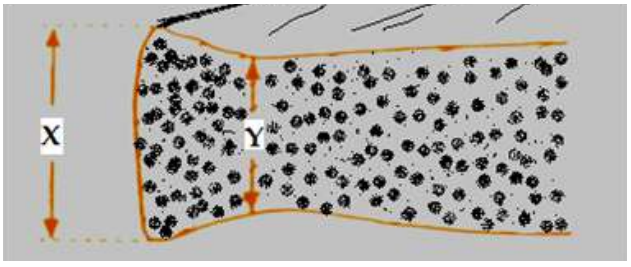

Fig.2 Method for evaluating deformation

2.9 Evaluation of warping

The warping defects (Twisting, Cupping, Bowing, and Crook) of experimental samples were observed and classified into three levels (slight, medium, and high) using the Rasaily (1993) classification method. The prevention methods for these warping levels were adopted based on Terazawa's (1965) recommendations. Supposing that the samples were found to be in a high-level warping category; the initial drying conditions, such as Initial DBT (10%), Initial WBD (15%), and of Final DBT (5%), should be reduced (Proposed by Terazawa (1965)).

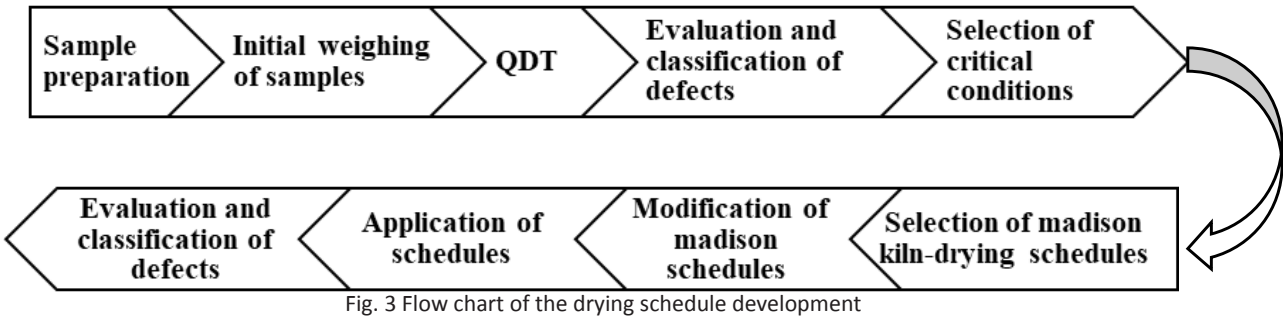

Fig. 3 Flow chart of the drying schedule development

2.10 Drying schedule development

In this study, the highest defect score in each experiment was used instead of the overall mean value of the defect score (*Kumar et al.*,2018) to obtain the least severe initial drying conditions. The corresponding remaining drying conditions of schedules were chosen from the tables prescribed by F.P.L. in Dry Kiln Operator's Manual, Madison, U.S.A. (Simpson, 1991). The flow chart of the entire procedure of drying schedule development is given in Fig.3.

The final stage of the kiln drying process is equalizing and conditioning treatment. Equalizing treatment condition prevent unequal final MC and stabilizes the specified MC of end products. Conditioning aids in the alleviation of residual compression stresses in the wood surface through plasticization.These treatments were performed based on the prevailing condition of the region.

2.11 Test of experimental kiln drying schedules

Pre-dried (up to 35%) boards of 25 mm thick and 50 mm thick coconut palm wood were stacked with 20 mm strippers, and both packs were dried separately using the experimental kiln-drying schedules.The first pack contained 65 boards of length 1.5 m to 2 m with a width of 100 mm and 25 mm thickness. The second pack included 42 boards of length 1.5 m to 2 m with a width of 100 mm and 50 mm thickness. Both groups were high-density boards selected based on visual grading. Five boards (known as sample planks) were randomly selected from each pack to measure MC and to observe defects before and after each drying stage.

2.12 Drying defect evaluation of planks

The first-type defect (surfaceand end checks) observationswere carried out in sample planks during the initial stage of the drying process at 4-hour intervals on the first day and twice on subsequent days. After drying, the degree of all defects was noted and scaled using the classification methods of Terazawa (1965) and Rasaily (1993).

3 Results and discussion

3.1 Basic density (kg/m³) and MC (%)

The mean density of 25 mm thick samples was 731 kg/m³, with a density ranging from 734 to 729 kg/m³, where as the mean density of 50 mm thick samples was 692 kg/m³with a density ranging from 691 to 702 kg/m³. Coconut palm wood has been classified into three groups: Dermal wood (high-density wood(>600 kg/m³)), Sub-dermal wood (medium-density wood (400 kg/cm³ to 590 kg/cm³)) and Core wood (low-density wood (<400 kg/cm³)) (Arancon, 2009). All the selected wood samples were under the dermal wood category.

The MC of coconut palm wood varies from 50% (bottom) to 400% (top) in green conditions (Killmann, 1983). MC increases significantly with stem height from the periphery to the centre of the coconut palm wood and is also negatively related to basic density (Romulo and Arancon, 1977). The mean MC of samples 25 mm thick was 44%, while the mean MC of 50 mm thick samples was 46 %.

3.2 Drying defects

The result of defects that occurred during QDT is shown in Fig.4.The summary of the adopted defect classification and corresponding Madison kiln drying schedule of two different thickness samples are given in Table 1. The most significant drying defects observed in 25 mm thick samples were surface checks, end checks, and twisting. The highest degree of the defect was six, which ranked to surface check (Fig.5a). Twisting was found to be another serious defect and classified as high-level. Warping (except twisting), internal checks, and deformation were less severe defects.

Surface and end check scores of 50 mm thick samples varied from a minimum score of 1 to a maximum score of 8. The surface check was the most

Samples Thickness	Average MC (%)	Adopted Classification of Defects					Proposed critical drying condition			
		Surface checks	End checks	Internal check	Deformation	Adopted	Initial DBT	DBT WBD	Final DBT	Corresponding Madison kiln schedule code
25 mm thick	44	6	5	4	2	6	50	2.3	80	T6-B1
50 mm thick	46	8	6	4	4	8	45	1.8	80	T4-B1

Table 1.Summary of adopted defect classification and corresponding madison kiln drying schedule

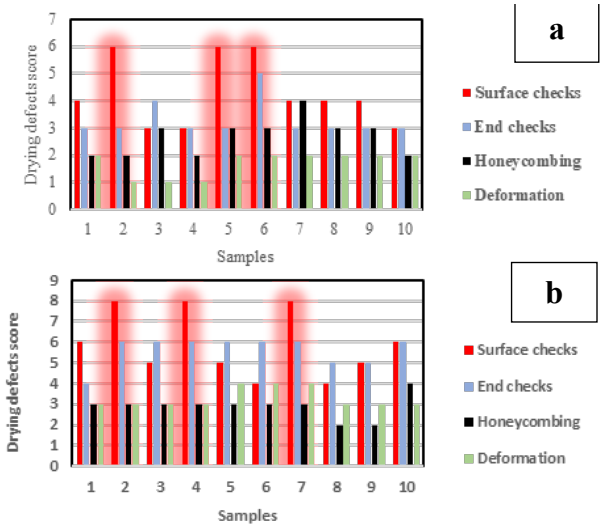

Figure 4.Degrees of defects in (a)25 mm thick samples and (b) 25 mm thick samples

severe defect, with a score of 8 (Fig.5b) and the other three defects, end checks, internal checks, and deformation, received scores of 6, 4, and 4, respectively. Only twisting was a serious warping defect classified as high-level.

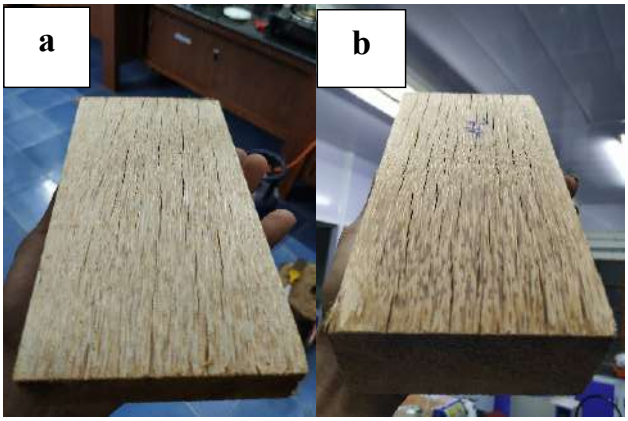

Figure 5. Surface checks observed initial stage QDT in (a) 25 mm thick and (b) 50 mm thick.

3.3 Drying rate during quick drying

QDT showed that the drying rate of samples with a thickness of 25 mm was higher than that of 50 mm (Fig.6).

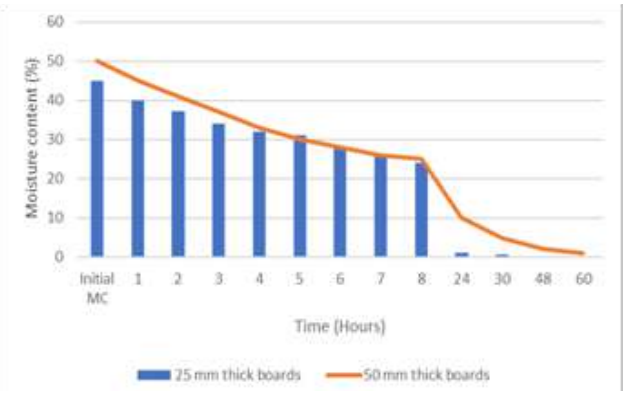

Fig.6 Drying rate of samples with two different thickness

3.4 Drying schedules

General drying schedules T6-B2 for 25 mm thick and T4-B1 for 50 mm thick coconut palm wood were adopted based on initial drying conditions. These drying schedules were further modified by reducing the initial drying conditions due to the presence of high-level twisting in samples and by changing final drying conditions to achieve the target permissible moisture content (EMC) (we chose 12% as our target MC).

The EMC of the coconut palm wood floor should be 8% or 10%, or 12% (Permissible EMC for general flooring purposes) for the different zones of India (IS 287-1993). If the flooring is installed in EMC conditions, the coconut palm wood is not going to shrink and swell. The best practice of wood seasoning is a combination of air and kiln drying (Rojo *et al.*,1988).

Coconut palm wood planks were pre-dried (air-dried) up to 35% and then kiln-dried. The results unveiled that the schedules are acceptable for high-

MT6-B1 (Modified T6-B1)						Time (Hours)
MC %	DBT	WBD	WBT	RH %	EMC %	
>35	45	2	43	90	19	215-228
35-30	54	2	52	89	17	
30-25	60	3	57	84	14	
25-20	66	6	60	74	10	
Equalization	62	8	54	60	12	4
Conditioning	62	13	49	54	8	7

Table 2. C. nucifera drying schedule for 25 mm thick boards

MT6-B1 (Modified T6-B1)						Time (Hours)
MC %	DBT	WBD	WBT	RH %	EMC %	
>35	39	2	37	89	19	220-240
35-30	49	2	47	86	18	
30-25	54	3	51	86	17	
25-20	60	6	54	73	11	
Equalization	57	8	49	64	12	5
Conditioning	57	19	38	52	8	9

Table 3. C. nucifera drying schedule for 50 mm thick boards

density coconut palm wood. Recommended kiln drying schedules are given in table 2 (MT6-B1) and table 3 (MT4-B1) for 25 mm and 50 mm boards, respectively.The drying time in MT6-B1 should be 9 to 10 days. In contrast, the drying time for MT4-B1 should be 10 to 11 days.

3.5 Moisture content and density of planks

The average MC of the selected planks was calculated to set the schedule conditions (temperature and relative humidity). The density was calculated to ensure that the planks fell under the high-density category. The mean density was above 650 kg/m³.

3.6 Drying defects of planks

While shifting the packs from the air to the kiln, very few checks and warping defects were observed. There was no further grading undertaken. Kiln-drying schedules were tested in an electric kiln-drying machine (Fig.7). The results showed that the schedules could produce adequate seasoned coconut wood planks. However, Surface checks were found to be more prevalent in 50 mm thick planks than in 25 mm thick planks (the maximum score awarded for 50 mm thick samples was three, and for 25 mm thick was two). There were no serious defects observed, such as internal checks or deformation

Fig.7(a) Planing, (b) Planed samples, (c) Sampling, (d) samples for QDT, (e) samples for physical property measurements, and (f) Kiln drying

3.7 Coconut palm wood flooring

Despite its excellent physical, mechanical, and decorative properties, coconut palm wood is susceptible to biodeterioration under normal conditions.However, coconut palm wood is the best flooring material.In this study, coconut palm wood was successfully kiln-dried and used for flooring (Fig.8).Mohmod and Tahir (1990) recommended

Fig.8 Coconut palm wood (25 mm thick) tongue and groove (T&G) samples on a coconut flooring

coconut palm wood (high-density) flooring in high-traffic areas. Fathiet al. (2014) pursued similar work with palm trees and observed that the mechanical strength of coconut palm wood was greater than that of oil palm and date palm. Bailleres *et al.* (2010) successfully developed flooring products from coconut palm wood for the Australian and European markets.

4 Conclusion

The checks in the early drying stage in the kiln were very mild. No serious defects were observed, such as internal checks or deformation. However, surface checks were found to be more prevalent in 50 mm thick planks than in 25 mm thick planks. The study unveiled that the schedules are suitable for producing high-density seasoned coconut palm wood with minimal defects for flooring. Boards with a thickness of 50 mm can be dried with an initial temperature of 39°C, an initial relative humidity of 89%, an initial wet bulb depression of 2°C and a final temperature of 57°C [MT4-B1].

On the other hand, 25 mm thick boards should be dried with a rigid drying schedule with an initial temperature of 45°C, initial relative humidity of 90%, initial wet bulb depression temperature of 2°C and final temperature of 62°C [MT6-B1]. The drying time in MT6-B1 should be 9 to 10 days. In contrast, the drying time for MT4-B1 should be 10 to 11 days.The drying time of these schedules can be optimised by changing the drying conditions using a trial-and-error method.

Acknowledgement

This research was supported and funded by the Kerala Agricultural University (KAU), Thrissur, Kerala, India, and the Indian Council of Agricultural Research (ICAR) under its National Agricultural Higher Education Project (NAHEP)-Centre for Advanced Agricultural Science and Technology (CAAST) for KAU.

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Skill Development Training Programme for SC and ST Youth in Coconut Cultivation Production

A skill development training programme in 'Coconut cultivation technologies' for Scheduled Caste and Scheduled Tribe youth under SCSP and TSP schemes is being held at ICAR - Central Plantation Crops Research Institute (CPCRI), Kasaragod. The training programme which commenced on 1st August 2023, being attended by 21 trainees is having sessions on Neera Production and Value Addition, Planting Material Production in Agro-techniques in Coconut and Computer Application, Office Automation and E - Office Management Skills.

The training was formally inaugurated by Smt. Mini P. John, Principle Agriculture Officer, Kasaragod. Dr. K. B. Hebbar, Director ICAR - CPCRI, Kasaragod in his presidential address urged the trainees to make use of the facilities of CPCRI to upgrade their working skill associated with coconut farming to improve their livelihood. The training programme will continue up to 31st March 2024.

Circular Agriculture in Coconut

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Circular agriculture and circular economy in agriculture are terms in vogue in recent times with the increased relevance to move towards sustainable forms of development. Sustainable development refers to development that meets the needs of the present without compromising the ability of future generations to meet their needs. There should be social progress which recognises the needs of everyone; at the same time development should happen with effective protection of the environment too, through prudent use of natural resources and maintaining high and stable levels of economic growth and employment.

Environment was considered as a resource in abundance earlier; it was not only the provider of all resources – both energy and materials. Environment was also the sink into which all garbage of production and consumption were dumped. A stage has reached now that the resources that were in abundance have turned scarce and the waste sink capacity of the environment has reduced that it cannot absorb much garbage, It is in this context that the concepts of sustainable development and circular economy have emerged because through climate change and the accompanying disasters, environment has taught mankind that if we do not change, environment will reshape our behaviour.

Circular agriculture has emerged alongside the discussions on the environmental impact of conventional agriculture. In a linear economy, raw materials are used for production of diversified products which are used in day-to-day life, but which also generate residual waste. In circular economy, the concept is to undertake sustainable production, followed by sustainable use with recycling of resources and products undertaken at all stages. Countries have increased their food production to feed the growing population, but this has come at a very high cost for the environment. This is more significant in the case of degradation of soils and the over-use of fresh water resources which are extracted at high rates due to resource intensive agriculture.

Circular agriculture is a way to the sustainability of the farm. Under this concept, the focus is on the use of minimal amounts of external inputs, closing the nutrient loops, regenerating the soils and minimising the impact on the environment.

Concept of Circular Agriculture:

As per the UN policy brief on Circular Agriculture for sustainable rural development, circular agriculture is a way to the sustainability of the farm. Under this concept, the focus is on the use of minimal amounts of external inputs, closing the nutrient loops, regenerating the soils and minimising the impact on the environment. Through this, the technological and scientific advances and innovations are closely integrated with an aim to minimize waste, optimize resource use, and promote sustainability in the agricultural sector. It is not to be seen as a shift towards past practices, but as a way of farming with nature. If implemented practically on a wide scale, circular agriculture can lead to reduction of use of natural resources thereby impacting the ecological footprint of agriculture.

In circular agriculture, all the various steps of food production right from the cultivation of crops to harvesting combined with the activities undertaken along the supply chain like processing, packing, transporting, marketing, consuming and disposing of food needs to be undertaken with a view to promote sustainable development. Circular agriculture calls for integrating of crops and livestock, water recycling and waste water reuse and agroforestry. All these contribute to prudent use of natural resources and inputs, reduced use of chemicals and reduction of emissions of carbon dioxide. The promotion of zero budget natural farming through policy support by the Government is expected to pave the way for encouraging small holder farmers to move the path of circular agriculture.

Adaptability of circular agriculture in coconut :

The approach of circular agriculture is highly relevant in horticultural crops and specifically for coconut.

Suitability to small holders :

The move to circular agriculture gives more emphasis on promotion of small holder farming which suits a crop like coconut in which more than 90% of the farmers fall in the category of small and marginal. Circular agriculture is also associated with organic farming and more of mixed farming for which also coconut is one of the most suited crops. Coconut plantations are largely not mono-cropped and have intercropping and mixed cropping to a large extent. The adequate spacing in coconut plantations which are maintained commercially also allows for a mixture of crops. Progressive coconut farmers are involved in integrating mixed farming too. Studies have demonstrated the potential environmental and economic advantages of mixed livestock farming over specialised systems like mono-cropping.

Water use efficiency:

Recycling and reuse of water is an important part of circular agriculture water management. Coconut is a crop which is very sensitive to nutrient and water availability. Water is a very crucial input impacting at all stages from inflorescence initiation to final mature nut production. Practices like drip irrigation, rain water harvesting etc in coconut plantations would not only stabilise yields but also add to replenishing of ground water. These practices have been encouraged over the years by the Government through various schemes which are actually sustainable agricultural practices paving the way for circular agriculture. There is potential for farmer organisations in promoting efficient use of resources on a community basis. A PPP mode or a backward integration of industry with the farmer organisations could also be undertaken, the recent example of the Kalpavriksha initiative by Marico promoting all aspects of cultivation including restoration and rejuvenation of farm ponds and construction of new ponds. Reusing waste water or treated water for agricultural irrigation can reduce pollution, ensure more water conservation and provide additional resources for recharging aquifers. Livestock rearing generates a substantial amount of waste water which is rich in organic matter and containing nutrients important to agriculture.

Closed-Loop Systems:

Circular agriculture encourages closed-loop systems where waste and by-products from one stage of production become inputs for another. In horticulture, this can involve using organic matter from crop residues to improve soil fertility, or using organic waste for composting and mulching, reducing the need for external inputs. The vegetative matter in coconut which after production of diversified products, could be used for production of organic manures.

Resource Efficiency:

The objective foreseen in circular agriculture is to capitalise on the synergy that exists between crops and livestock thereby creating a circular food system wherein the part of the crop production that is suitable for human consumption is consumed by humans and the residual flows including the grass and herbs in the land are consumed by animals, In turn the manure from animals and the residual vegetative matter goes back to land to make it healthy and improve crop yields. In the case of coconut, all parts of coconut could be used for diversified products. Circular agriculture thus promotes the efficient use of these resources.

Waste Reduction:

Circular agriculture emphasizes reducing waste by implementing practices like composting, recycling, and the utilization of by-products. This reduces the environmental impact and contributes to sustainable farming. In the case of coconut, it is aptly called the Kalpavriksha since all the parts can be put to a variety of uses, thus making it a crop of zero waste. Coconut

farming generates various forms of waste. Coconut husks and shells are now by-products of coconut fetching more value in the market than the main food products, at times. And the products go in for use on conservation agriculture, renewable energy etc which are also contributing again to sustainable modes. Circular agriculture promotes the utilization of these by-products. For example, coir is a valuable material for soil improvement and erosion control while coconut shells can be used for making activated carbon or as a source of bioenergy.

Sustainable Processing:

Circular agriculture extends to the processing of coconut products. Sustainable processing practices can reduce waste, energy consumption, and water usage during the production of coconut oil, milk, and other coconut-based products. Utilisation of the waste water generated for other suited needs, production of biogas which is a form of renewable energy etc are methods by which sustainability in processing could be achieved.

Biodiversity and Ecosystem Services:

Circular agriculture supports biodiversity conservation by reducing the use of chemical inputs, promoting habitat restoration, and enhancing ecosystem services, which are critical for horticultural crop production. Coconut is a crop which relies on ecosystem services such as pollination, pest control, and soil health. Integrating apiculture in coconut gardens can serve to increase pollination and fruit set. It also provides added revenue from honey. Establishing coconut based farming systems and adopting biological methods for crop protection contributes to enhancing the biodiversity in terms of flora and fauna in coconut plantations.

Health and nutritional attributes:

Circular agriculture with more diversity of production is associated with better health and nutrition; the studies on the nutritional and health attributes of coconut products has been intensified since the onset of the 21st century with conclusive clinical studies being undertaken by different coconut producing and consuming countries. If coconut water as a beverage formed the coconut craze during the last decade, coconut milk is emerging as the most sought-after product with growing consumer consciousness for foods of plant origin. Coconut emerges as one of the most suited crops in terms of its nutritional and health attributes too.

Sustainable Packaging:

Packaging is a significant aspect of horticultural supply chains. Circular agriculture encourages the use of sustainable and recyclable packaging materials, reducing the environmental footprint associated with packaging and distribution. Different technologies have emerged in producing sustainable and biodegradable packing materials from coconut waste, especially tender coconut waste. Coir and coir products also offer potential options for sustainable and environment friendly packing materials.

Local Economic Development:

Circular agriculture can support local economies by creating opportunities for value addition at the community level. Small-scale coconut farmers can benefit from circular practices such as coir production or the processing of coconut-based products, adding value to their crops and increasing income. Coconut based industries could generate rural employment and thereby offering livelihood security and social security thus leading to local economic development.

Consumer Preferences:

Consumer preferences are shifting towards more sustainable and environmentally friendly products. Horticultural producers can benefit from circular agriculture by aligning their practices with these preferences, potentially leading to higher market demand and premium prices. In the case of coconut, the market has shown evidence in this regard with the increased demand for coconut water and coconut milk in the past decade. By-product utilisation of the residue in production of virgin coconut oil and coconut milk by converting them into dietary fibre, dietary protein, flour etc also works on aligning the innovative products in accordance with the health attributes they possess.

Market Demand:

There is a growing global demand for sustainable and environmentally friendly coconut products, including coconut oil and coconut water. Implementing circular agriculture practices can help coconut producers meet these market demands and potentially access premium markets.

Resilience to Climate Change:

Circular agriculture practices can enhance the resilience of horticultural systems to climate change impacts such as extreme weather events, drought, and changing pest and disease patterns. For example,

improved soil health through circular practices can enhance water retention and reduce vulnerability to drought.

Circular agriculture is highly relevant in horticultural crops due to its potential to improve resource efficiency, reduce waste, enhance sustainability and align with changing consumer preferences. The emerging importance to circular agriculture will indeed reflect in market through appropriate certifications which will attract premium prices. Implementing circular principles in production can contribute to more environmentally and economically sustainable farming practices in the coconut sector.

Policy support :

Circular agriculture is a phenomenon that could be adopted only with policy support. It aims to address the rising concerns of unsustainability in food production, destruction of soils and degradation of natural resources like land and water. For farmers to adopt circular agriculture, there should be a willingness from the side of the consumers to pay more for quality products produced. Reduction of food wastage should start in every household. We are a country that produces more than our needs thereby feeding the global population too through export. The amount of food, for instance horticultural products that is wasted accounts for more than 30% which itself is more than what many countries produce. If we are able to support circular agriculture and reuse the resources and reduce wastage, India can emerge as the food basket of the world.

Investments in technologies and research for circular agriculture:

A shift to circular agriculture may be farming with nature, but it is not going back to traditional practices; instead, it is aligning the practices with nature by adopting the advances in science and technology. Research is needed to address the yield gap while adopting circular agriculture; another potential area is use, reuse and recycling of water. A number of research institutions under ICAR and CSIR have ventured into various research which add value to products, by-products, residual waste etc; a good example is the research currently progressing at CSIR-NIIST in better effluent treatment for desiccated coconut industry using anaerobic and aerobic modes funded by DST. Modified technology at near zero energy cost is most suited. Small holder farmers could also be supported in achieving sustainable use of natural resources.

Incentivisation and strengthening of institutions:

Existing subsidies which undermine the sustainable use of natural resources need to be eliminated. This also applies to policies and subsidies that incentivise the over use of fertilisers, water or energy. These could be phased out in a planned manner. Policy formulation could be aimed at subsidising practices that promote circular agriculture. For instance, subsidies could be extended to farmers who adopt an easily verifiable organic soil fertility management practice, which sequesters significant amount of carbon. Water and land tenure rights through policy making is another option.

International cooperation:

Transition towards circular agriculture and sustainable development is a process in which all countries have a stake. Agriculture and food production has a very significant impact on the society and environment. International cooperation for technology transfer and capacity building programmes, setting norms and standards for waste management, reporting on food loss and waste etc are to be undertaken. Local supply chains have become increasingly relevant after the COVID-19 pandemic. There is need to upgrade the infrastructural, technological and marketing skills.

Climate change and the hazards and calamities that accompany affect all the countries globally. The exploitation of environment which comprises of the lithosphere, geosphere and the atmosphere has proceeded past limits. The environment had a stage till which it was able to recoup and get back to the original stature; but unfortunately, we have surpassed all those limits that the environment is now compelled to retaliate or self-adjust. If action is not initiated now, we may proceed to a stage from where there is no way to get back. Since adoption of circular agriculture is particularly suited to labour intensive small holder farming and coconut being a crop where more than 65% of the cost of cultivation is labour, Circular agriculture in coconut will contribute to more inclusive and gender sensitive economic development in rural areas.

Need to Focus on Farming System Approach for Sustainable Production and Higher Income from Coconut : 'Kerakesari' Dominic

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"Coconut growers are now having difficult times due to the low price of coconut. Market interventions and similar support mechanisms are to be effectively implemented by the government to protect the interests of coconut growers during these tough times. "I am able to manage the difficult situation because of the attractive market price available for nutmeg and arecanut which I have mixed cropped in my coconut garden. Farmers need to focus on farming system approach effectively integrating intercrops and enterprises instead of cultivating coconut as a monocrop" opined Mr. Dominic Mannukusumbil, a well known award winning coconut grower from Anakkampoyil, Thiruvambady grama panchayat of Kozhikode district, Kerala.

Generally, when there is a sudden price crash or price stagnates at low level farmers start neglecting coconut palms without adopting any crop management practices which results in low productivity and finally low income from farming. Adoption of coconut based multiple cropping and integrated farming system is very relevant for ensuring sustainable productivity and higher income from coconut farming especially when farmers face diffculties due to low price or market fluctuations.

In fact Mr Dominic was repeating exactly what he stated nine years ago in 2014 while interviewed for Indian Coconut Journal. According to him to make the coconut farming sustainable and remunerative the basic principle is 'not to leave any piece of land in

the farm unused and adopt measures to conserve the basic natural resource viz., soil and water'.

Dominic always repose good faith in coconut and he carries out all the crop management practices in his farm according to the principle of efficient utilization and conservation of soil and water, even when the market price of coconut is not that attractive. The impact of adhering to the basic principles of sustainable agriculture is there to see in his nine acre coconut farm located in the hilly terrain at Anakkampoyil in Kozhikode district.

Mr. Dominic maintains nine acre coconut farm in the sloping hilly terrain with 340 coconut trees of West Coast Tall variety, out of which five acres are irrigated and four acres rainfed. Besides about 40 coconut trees of 'Kera sankara' TxD hybrid variety are also cultivated in his farm. There are about 300 nutmeg trees as the main mixed crop in the irrigated part of the coconut garden. Nutmeg has been planted in the centre of four palms. Earlier, he was also cultivating cocoa as another mixed crop in his coconut garden which he has removed mainly due to the crop loss suffered from squirrel and civet infestation. During 2017 he purchased two acre agricultural land in the nearby area with rubber trees. After purchasing the land he cut the top of rubber trees and pruned them and planted pepper vines of Panniyur-1 variety using the trimmed rubber trees as standards. The pepper vines have established very well. He has planted 105 coconut palms of 'Kuttyadi' local ecotype of WCT variety and about 200 arecanut palms of Mohitnagar variety.

He adopted a very innovative method for planting coconut seedlings. The innovation is pertaining to digging large pits for planting. Pits of one metre deep and 2.5 metres diameter are dug for planting coconut seedling. He says the cultural operation of basin opening for coconut palms can be done away with for 70 years if large sized pits are taken for planting. Another advantage of large pit size is that attack of wild boars can be avoided which is often a problem experienced by coconut growers.

Five clove trees are also there in the coconut garden. But Mr. Dominic is not happy with clove as a mixed crop in coconut garden because of the difficulty in harvesting clove when it grows tall. Besides these perennial crops, banana, elephant foot yam, colocassia, cow pea, bittergourd, snake gourd, tapioca, turmeric and ginger are also cultivated as intercrops in a small scale. Altogether about 400 arecanut palms are mixed cropped in the coconut garden. The animal husbandry component of his coconut based farming system includes one milch cow, ducks, and few poultry birds in backyard rearing mode.

A perennial stream flows through the farm which provides assured water for irrigating his farm where inter/mixed cropping is practiced. Earlier, irrigation was done through sprinkler system. But now sprinkler system has been removed and irrigation is done through basin method using hose pipes." When sprinkler method is adopted for irrigation lot of water get wasted and hence it is removed" said Dominic. He is aware that drip irrigation is the ideal irrigation method for coconut as it is a water saving method and is having high irrigation efficiency. He is planning to

install drip irrigation system in his coconut orchard.

Stone pitched bunds are constructed throughout the farm in the sloping terrain for soil and water conservation which are repaired/reinforced as and when required. Maintenance of very wide basins for coconut and mixed crops is a unique feature of agrotechniques adopted by Mr Dominic. He says providing wide basin is important for effective moisture conservation. Coconut leaves, husks and other biomass available from the farm are used for mulching the basins.

He gives utmost importance to balanced application of nutrients to coconut and intercrops. During the month of May mulch materials spread in the basin are drawn back to the periphery to avoid surface root proliferation. After that lime @1kg per palm is applied in the coconut basin and forked in. After two weeks organic manure will be applied @ 40 kg cow dung per palm and will be covered using the loosened soil and mulch materials drawn to periphery of the basin in the basin. In alternate years bone meal @ 5 kg per palm or ground nut cake @ 2 kg per palm will be applied in place of cow dung. Liming and organic manure application to the coconut palms will be completed before June. Chemical fertilizers are applied to coconut palms during September. About 1 kg muriate of potash, 500 g each of urea and rajphos are applied per palm. Whenever yellowing of coconut leaves is observed he applies Magnesium sulphate @ 500 g per palm. Besides, 100 g borax also is applied per palm.

About 1.5 kg muriate of potash and 750 g each of urea and rajphos are applied per nutmeg tree every year besides application of organic manure in the form of bone meal @ 5 kg per tree and cowdung @ 30-40 kg per tree. Only organic manures are applied to pepper vines @ 10 kg cow dung and 1 kg bone meal per vine per year. For arecanut palms organic manures are provided @ 10 kg cow dung and 1 kg bone meal. Besides, 250 g each of urea, rajphos and muriate of potash are also given to each arecanut palm per year.

In Dominic's farm pest and disease incidence is low in nutmeg except for the fruit rot and fruit drop and drying of branches from tip downwards due to fungal infection. Application of 1% Boradeaux Mixture is effective against these problems. However, yellow leaf disease of arecanut is diffcicult to manage, though he is trying hard to sustain the productivity through balanced fertilizer application. According to Mr. Dominic nutmeg is the most suitable mixed crop for planting in coconut garden. Because of its long economic life, low incidence of pests and diseases, low cost of cultivation and increasing yield and income every year. Soil is not disturbed in the basin of nutmeg tree. Manures and fertilizers are applied in the basin and just forked in. If root proliferation is observed in the surface of the basin soil is brought from outside and spread in the basin.

Even though arecanut is not commonly recommended as a mixed crop in coconut garden, according to Dominic it will be a profitable mixed crop if coconut is planted with sufficient spacing ie eight metres or more. However, if coconut is planted with less spacing yield of both coconut and arecanut will be adversely affected as experienced by many farmers. Since coconut is planted with more than eight metres spacing he is able to get good yield from

both coconut and arecanut. In the sloping terrain of the rainfed coconut garden where mixed cropping of arecanut is practiced proper soil and moisture conservation practices including stone pitched contour bunds, mulching etc are adopted.

Part of the cow dung from the animals in the farm is applied to coconut and component crops. Some quantity of cowdung is used for making biogas. Biogas slurry is given back to the crop as manure. Animals are fed with green grass available from the farm and also homemade animal feed thus reducing the cost of maintenance of animals.

On an average Mr. Dominic is able to harvest 175 coconuts per palm annually. Average yield obtained from nutmeg is 4 kg nuts and 500 g mace per tree. From arecanut as mixed crop he is getting an average yield of two kg chali per palm per year. He could get 500 kg pepper from 350 vines during the last season. On an average 15 lit milk is obtained per cow. Apart from the cultivation of crops, Mr. Dominic is also managing an agricultural nursery for the production and sales of planting material of coconut, arecanut and nutmeg. The nursery is approved by the Department of Agriculture, Government of Kerala.

One important factor for his success in farming is his and family members' active involvement in all the farming activities. There are three permanent workers in his farm. He is not merely acting as manager and giving instructions to the labourers in the farm but physically work along with them, which he says, is instrumental for ensuring a sincere commitment from the labourers. His mother Mrs Eliyamma, aged 83 years, also is actively involved

in farming related activities in whichever possible ways. Mrs. Elsy, Dominic's wife, is also a source of support in farming. His elder son, Mr. Jubin is also into farming and he owns a six acre farm. Mr Jiffin, his younger son trained in hospital management is employed in U K.

Dominic, who is now 64 years old, has received many awards and recognitions for his tremendous achievemments and innovative practices in coconut farming. He was selected as the best farmer at gramapanchayat, block and district level. In the year 2011, he was bestowed with the prestigious 'Kerakesari' award instituted by Department of Agriculture, Kerala for his achievements in the scientific management of coconut. In 2015 he received the state level "Karshakothama" award for the best integrated farm instituted by Department of Agriculture. In 2016 he was bestowed with the national award instituted by Coconut Development Board for the best coconut farmer. In the same year, when ICAR-CPCRI organised the centenary celebrations Mr Dominic was one among the 100 innovative and successful coconut farmers selected from various states of the country who were honored in the function. Mr. Dominic maintains regular contact with research institutions like CPCRI, IISR and extension agencies like Krishibhavan, ATMA etc. Video documentation on his innovative coconut farming methods are widely circulated through social media. He is a much sought after resource person and is always happy to share his experiences with other farmers. Dominic's coconut farm serves as a farmer's field school and is often visited by farmers, extension personnel, students and other stakeholders.

(Contact: Mr. Dominic M. M., Mob: 8281076029)

Integrated management of red palm weevil in coconut garden - A success story from Bayar, Kasaragod

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Crop loss due to the incidence of pests and diseases is one of the major constraints in coconut production experienced by the farmers. Rhinoceros beetle (*Oryctes rhinoceros L.*) and red palm weevil (*Rhynchophorus ferrugineus Oliv.*) are the key insect pests of coconut. Rhinoceros beetle makes the wounds on palm by boring the spindle leaf, petiole and unopened spathe, which often serve as the entry point for bud rot disease fungus and red palm weevil infestation. Red palm weevil is a devastating pest of coconut. Gravid females locate the host by volatile cues emanating from the wounds and lay the eggs in wounds, cracks and crevices present in crown, trunk or in bole region. Hatching larvae extensively tunnel into the trunk and feed voraciously on internal content. Concealed nature of the pest and feeding on central core tissues without explicit damage symptoms at times is a hurdle in its effective management. Early detection and systemic approach of integrated pest management can help in successful management of these pests.

Recently, a fatal incidence of red palm weevil was noticed in a coconut farm owned by Mr. Raheem at Bayar (Longitude E 75º0'14.31108'; Latitude N 12º42'31.1328) in Paivalike Village of Kasaragod District, Kerala. It is a well maintained 35 acres of farming system located in the hilly terrain with coconut as principal component. It includes, 550 bearing coconut palms, 225 non-bearing palms, intercrops like rambutan, Jack, star fruit, banana, cashew, pepper and papaya. Besides, a poultry unit of 10,000 birds and a dairy unit with 19 Holdstein Friesian cows are also integrated with the farming system. Mr. Raheem has been regularly seeking technical advice from scientists of ICAR- CPCRI Kasaragod for planting and management of coconut and other component crops in the farm.

By the middle of 2019, bearing palms encountered a severe attack of red palm weevil. When it was brought into the notice, a team of scientists of ICAR- CPCRI visited the farm and suggested control measures. About 35 (6.4%) palms were infested by RPW through crown region. By the time of diagnosis and implementation of curative crown pouring with insecticide, 29 palms had died by crown toppling and 6 palms recovered. To recover those palms, two

Crown infestation of RPW

rounds of crown pouring with imidacloprid 17.8 SL @ 1 ml/L had to carry out at 30 days interval. All toppled crowns and dead palms were burn into ashes in order to prevent the breeding of RPW in field. At the same time, prophylactic measures were adopted to protect the healthy palms from RPW infestation. Prophylactic treatments included, leaf axil pouring of imidacloprid 17.8 SL @ 0.5- 0.7ml/ L, leaf axil filling with 1:1 mixture neem cake and sand @ 500g per palm, leaf axil filling with 1:40 mixture of chlorantraniliprole 0.4 WG and sand @ 250g/palm, leaf axil placement of naphthalene balls sequentially at monthly interval. The prophylactic protection measures adopted were absolutely successful in preventing RPW entry through the crown region. The field was totally free from RPW infestation in rest of 2019 and 2020. But in 2021, 63 palms were again found infested (12.1%) by RPW through the bole region. As the crown portion become unfit for consumption by the weevil due to prophylactic leaf axil fillings, systematically and the bole region served as the entry point. Mulching covering the bole region hindered the closer observation in bole region and made difficulty in identification. However, timely diagnosis and curative stem injection of imidacloprid @ 1ml/ L could save the affected palms. There was 87% recovery *ie.*, 55 palms were saved. Eight palms were lost as the infestation was in later stage. In order to protect healthy palms from bole entry of RPW, one round of prophylactic basin drenching of chlorpyriphos was done @ 5 ml/ L wetting the collar and basal portion of the trunk was suggested. Prophylactic leaf axil treatments were continued as discussed earlier, but the interval between the treatments was increased to 45 days, instead of 30 days. All dead palms were burnt in order to reduce the pest population. The utmost care was taken to avoid causing injury to the palms; while cutting green fronds, a portion of petiole (1.2 m length) was left behind in order to increase the proximity of cut end and the crown. In the year 2021, three palms were infested by RPW through bole regions, which were recovered by stem injection of imidacloprid @ 1 ml/ L in 2021, prophylactic leaf axil filling with repellents was done at 2 months interval and avoided the prophylactic use of imidacloprid and chlorpyriphos. In 2022, the crown entry (1 palm) of the pest was reduced to 0.002%, bole entry (3 palms) to 0.006% and the recovery percentage of infested palms increased up to 100%. The team of scientist from ICAR- CPCRI conducted regular visits to the coconut farm and monitored the proper adoption of IPM measures

Bole infestation of RPW

against the red palm weevil. Mr. Raheem, the farmer was very prompt in executing the IPM activities as per the recommendation of scientists. The success of integrated management of red palm weevil in Mr. Raheem's coconut farm is quite inspiring; as it has clearly indicated the systematic and scientific approach if adopted in pest management in coconut garden with the active involvement of farmers, crop loss can be avoided. Coconut growers in the nearby areas are also impressed by Mr. Raheem's success and are convinced about the efficacy and feasibility of recommended IPM practices against red palm weevil.

Constraints

There were also some practical difficulties in adopting the IPM in Mr. Raheem's garden

Lack of knowledge on diagnostic symptoms and failure in early detection of RPW incidence initially in 2019 caused the delay in adoption of curative treatment. Moreover, crown infestation is more fatal when compared to bole infestation, because it inflicts damage directly to cabbage and actively growing portion of the palm. Mulching at the base of the palm masking basal portion of the trunk and bole region made it difficult to detect the bole entry of the weevil. Non availability of labor for agricultural works is another problem experienced. Systematic monitoring and sequential leaf axil filling with repellents, curative crown pouring of insecticide and trunk injection with insecticides are labour intensive operations.

Bayar coconut farm

Conclusion

Since RPW is a fatal enemy of coconut less than 1 % pest incidence is considered as Economic Threshold Level. Systematic and regular surveillance activities will help in early detection of the pest incidence. Once the incidence in noticed, curative treatment with imidacloprid @ 1ml/L as stem injection or crown pouring (depending on the point of entry) is to be adopted without any delay. Based on the practical experience in managing RPW, refinements in IPM of RPW is suggested. Whenever the incidence of RPW is noticed, along with prophylactic leaf axil protection, prophylactic bole protection also needs to be adopted. If not, infestation of RPW through the bole region will occur in near future. It can be achieved by sprinkling neem cake around the collar region. Mulching need to be done in such a way that, it should not hinder the view of the collar region which enables the farmer to have closer observation and to effectively monitor the bole entry of weevil.

Based on the experience gained in the effective management of red palm weevil in coconut farm at Bayar, the following measures are suggested for the integrated management of the pest in endemic areas

1. Cut and burn all dead palms and debris which may serve as breeding ground for the weevil

Red palm weevil (Rhynchophorus ferrugineus Oliv.)

leaf axil filling

2. Avoid causing injury to the healthy palm. If there is any injury, swab it with insecticide or mud slurry in order to mask the volatile

3. Mulching to be done 5-10 cm away from the collar region, so that collar portion is clearly monitorable

4. Control rhinoceros beetle infestation and bud rot / leaf rot diseases which predispose RPW attack

5. Adopt prophylactic leaf axil filling with the following repellents at 30 days intervals sequentially in endemic areas.

a. Crown pouring with imidacloprid 17.8 SL @ 0.5- 0.7 ml/ L

b. Leaf axil filling with 1:1 mixture of sand and neem cake @ 500 g / palm

c. Leaf axil filling with naphthalene balls @ 12 – 15 g / palm and cover it with sand

d. Leaf axil filling with 1: 40 mixture of chlorantraniliprole (0.4 G) and sand @ 250 g /palm.

Prophylatic leaf axil filling intervals can be widened to 45 days - 60 days, once the pest incidence reduces to less than 1 %

6. Provide prophylactic bole protection as per given below

a. Prophylactic bole spraying or drenching with chlorpyriphos @ 5ml/ L (One round)

b. By sprinkling powdered neem cake around the bole region

7. Curative crown pouring / trunk injection with imidacloprid 17.8 SL @ 1 ml/ Lor with chlorpyriphos @ 5 ml/ L

8. Repeat the curative treatment if needed at 30 Days after first treatment

Feedback from the farmer

The most important problem I faced in my farm is the crop loss due to insect pest incidence, especially red palm weevil. However, the team of scientists from CPCRI Kasaragod was regularly visiting my garden and have been giving me proper guidance on the integrated management practices of this destructive pest. Labourers working in my farm were not having any skill in identification of the pest infestation. But, by the continuous training and constant guidance given by the scientists were quite beneficial in developing skill for early detection and diagnosis of this pest incidence. Besides, the demonstration of stem injection and crown pouring of insecticides were very helpful in practical learning of treatment imposition. Now my garden is totally free from red palm weevil infestation. Yet I am continuing prophylactic protection measures at quarterly interval as suggested by the scientists.

Mr. Raheem

Recently I introduced bee colony also into my farm. I am thankful to the team of scientists from CPCRI Kasaragod; Dr. Prathibha P. S., Dr. Thamban. C, Dr. P. Subramanian, and Dr. Vinayaka Hegde for their support and encouragement for carrying out the pest control measures and scientific management of my coconut garden.

Cultivation Practices in Coconut Garden
- September

Planting

In low lying areas, planting of coconut seedlings can be undertaken in small sized pits or on mounts raised to one metre above water table. Prevent accumulation of rain water in the seedling pits by ensuring adequate drainage. In regions like Tamil Nadu field preparation should be done for new planting.

Manuring

Circular basins of 1.8m in radius and 25 cm depth may be dug and green leaf or compost or farm yard manure at the rate 50 kg per palm may be spread in the basin. Two third of the recommended dose of chemical fertilizers may be spread over the green leaf or compost and covered. Application of 500 g N, 320 g P2O5 and 1200 g K2O per palm per year is generally recommended for adult plantations. To supply two-third of the above nutrients it is necessary to apply about 0.72 kg urea, 1 kg rock phosphate (in acidic soil) or 1.33 kg Super Phosphate (in other soils) and 1.33 kg of Muriate of potash (MOP). Under irrigated conditions, one fourth of the recommended dose of chemical fertilizers can be applied during September.

It is always recommended to apply chemical fertilizers based on the soil test results rather than going by the general recommendations.

Wherever Boron deficiency is noticed 100 g Borax may be applied in the basin. For coconut palms showing yellowing of leaves due to Magnesium deficiency, 0.5 kg of magnesium sulphate can be applied in the basins along with other fertilizers.

The above schedule of manuring is suitable for all the major coconut growing regions which are mostly benefitted by South-West monsoon during the season. In localities of Tamil Nadu, which are mostly benefitted by North- East monsoon the first dose (one third of recommended dose) of chemical fertilizers can be given during September. Under such situations, lime or dolomite or gypsum @ 1kg/ palm need to be applied two weeks before the first dose of chemical fertilizers are applied.

Green manuring

Wherever green manure crops are grown, plough in the green manure crop (after attaining 50 per cent flowering) and incorporate into the soil.

Intercultural operations

Ploughing/digging of interspace is to be undertaken to keep the plantation free of weeds. Care should be taken to avoid injury to coconut palm while ploughing.

Nursery management

Weeding should be done in the nursery. Five month old ungerminated nuts and dead sprouts should be removed from the nursery. In localities of Tamil Nadu, which are mostly benefitted by North-East monsoon, land preparation can be taken up for sowing seednuts.

Crown cleaning

Wherever crown cleaning has not undertaken during August the same may be done during this month.

Mulching

Mulching of palm basins can be undertaken during the second fortnight of September to conserve moisture

Plant protection

▶ *Integrated Pest Management*

▶ *Rhinoceros beetle*

Adopt mechanical method of control by extracting beetles with beetle hooks, without causing further injury to the growing point of the palm. The top most leaf axils may be filled with powdered neem cake/ marotti cake (*Hydrocarpus sp/ pongamia*) @ 250 g + fine sand (250g) per palm as a prophylactic measure. Fill the innermost three leaf axils with 4 g each of naphthalene balls covered with sand (12 g/palm) for juvenile palms. Placement of two perforated sachets containing *chlorantraniliprole a.i.* 0.4% (5 g) or fipronil (3 g) or one botanical cake (2 g) developed by ICAR-CPCRI and incorporation of the biomass of weed plant *Clerodendron infortunatum Linn.* in the cow dung/compost pit can also be done. The breeding sites may be treated with green muscardine fungus (*Metarhizium anisopliae*)

▶ *Red Palm Weevil*

Avoid causing injury to the palms, as they would attract the weevil to lay eggs. Mechanical injury if any, caused should be treated with coal tar. While cutting fronds, petiole to a length of 120 cm is to be left on the trunk to prevent the entry of weevils into the trunk. Removal and burning of palm at advanced stage of infestation would aid in destruction of various stages of the pest harboured in the trunk. Prophylactic leaf axil filling suggested for rhinoceros beetle is very essential as this pest pave way for red palm weevil.

If damage occurs in the crown, the damaged tissue has to be removed and insecticide suspension, *imidacloprid* (0.02%) @1 ml/L of water may be poured in. In case of entry of weevil through the trunk, the hole in trunk may be plugged with cement/tar and the top most hole is made slanting with the aid of an auger and the insecticide solution is poured through this hole with funnel.

▶ *Eriophyid mite*

Spraying on the terminal five pollinated coconut bunches with neem oil garlic soap mixture @ 2 per cent concentration (neem oil 200 ml, soap 50 g and garlic 200 g mixed in 10 litres of water) or spraying neem formulations containing 1 per cent azadirachtin @ 4 ml per litre of water or spraying palm oil (200 ml) and sulphur (5g) emulsion in 800 ml of water and root feeding azadirachtin 10,000ppm @ 10 ml + 10 ml water is effective. Along with the recommended dose of manures and fertilizers, 5 kg neem cake should also be applied.

▶ *Coreid bug*

Spray neem oil-soap emulsion (0.5%) on the pollinated bunches. The emulsion can be prepared by adding 5 ml neem oil and 8 g bar soap in one litre water.

▶ *Rugose Spiralling Whitefly*

No chemical insecticide should be sprayed on leaves. Apply 1% starch solution on leaflets to flake out the sooty moulds.

In severe cases, spray neem oil 0.5% and no insecticide is recommended. Install yellow sticky traps on the palm trunk to trap adult whiteflies. Encourage build up of parasitoids (*Encarsia guadeloupae*) and re-introduce parasitized pupae to emerging zones of whitefly outbreak.

In situ habitat conservation of the sooty mould scavenger beetle, *Leiochrinus. nilgirianus*

Integrated Disease Management

▶ *Bud rot*

Remove the infected tissues of the spindle completely. Two or three healthy leaves adjacent to the spindle may have to be removed, if necessary, for easy removal of all rotten portions and thorough cleaning. After removing the affected tissues apply 10% Bordeaux paste and cover the wound with a polythene sheet to prevent entry of rain water. The protective covering has to be retained till normal shoot emerges. Destroy the infected tissues removed by burning or deep burying in the soil. Spray 1% Bordeaux mixture to the surrounding palms

▶ *Stem bleeding*

Avoid burning of trashes near the tree trunk. Avoid injury to the tree trunk. The affected tissues should be completely removed using a chisel and smear the wound with 5% hexaconazole (5 ml in 100 ml of water) and drench the basins @ 25 lit. of 0.1% solution

Smearing paste of talc based formulation of *Trichoderma harzianum* on the bleeding patches on the stem can be done (The paste can be prepared by adding 50 g of Trichoderma formulation in 25 ml of water)

Soil application of *Trichoderma harzianum* enriched neem cake @ 5kg per palm and adopt recommended irrigation/moisture conservation practices.

▶ *Leaf rot*

Remove rotten portion of the spindle leaf and 2-3 successive leaves and pour fungicide solution containing 2 ml hexaconazole 5 EC in 300 ml water/ palm or talc based formulation of *Pseudomonas fluorescens* or *Bacillus subtilis* @ 50 g in 500 ml water/palm into the well around the base of the spindle leaf

Undertake prophylactic measures to prevent rhinoceros beetle attack

▶ *Basal Stem Rot/Ganoderma wilt*

Remove dead palms, palms in advanced stages of the disease and destruct the bole and root bits of these palms. Isolation of diseased palms from healthy palms by digging isolation trenches of 2 feet depth and one feet width around the basin can also be done. Avoid flood irrigation or ploughing in infected gardens to prevent spread of the inoculum.

Addition of 50 kg of farmyard manure or green leaves per palm per year and application of Trichoderma harzianum enriched neem cake@ 5 kg per palm and irrigating the palm once in 4 days and mulching around the basin is also useful.

Raise banana as intercrop wherever irrigation is possible Root feeding of hexaconazole @ 2% (100 ml solution per palm) or soil drenching with 0.2% hexaconazole / 1 % Bordeaux mixture @ 40 litre solution per palm can also be done.

Field sanitation

Special care should be taken to remove the organic debris/fallen trees etc in the coconut gardens in Kerala state affected by the recent heavy rainfall/ flood situation. ■

Market Review – July 2023

Domestic Price

Coconut Oil

During the month of July 2023, the price of coconut oil opened at Rs. 12500 per quintal at Kochi, Rs. 12600 per quintal at Alappuzha market and Rs.13800 per quintal at Kozhikode market.

The price of coconut oil closed at Rs. 13200 per quintal at Kochi, Rs. 13100 per quintal at Alappuzha market and Rs.14200 per quintal at Kozhikode market with a net gain of Rs. 700 per quintal at Kochi and Rs. 500 per quintal at Alappuzha market and Rs. 400 per quintal at Kozhikode market and it showed an upward trend during the month.

During the month, the price of coconut oil at Kangayam market opened at Rs. 10067 per quintal and closed at Rs. 11467 per quintal with a net gain of Rs. 1400 per quintal.

Weekly price of coconut oil at major markets Rs/Quintal)				
	Kochi	Alappuzha	Kozhikode	Kangayam
01.07.2023	12500	12600	13800	10067
08.07.2023	12500	12500	13500	10133
15.07.2023	12600	12600	13500	10400
22.07.2023	12900	12900	13800	10933
29.07.2023	13100	13000	14000	11275
31.07.2023	13200	13100	14200	11467

Milling copra

During the month, the price of milling copra opened at Rs.7800 per quintal at Kochi and Rs.7650 per quintal at Alappuzha and Rs.7900 per quintal at Kozhikode market.

The prices of milling copra closed at Rs. 8500 per quintal at Kochi market, Rs. 8350 per quintal at Alappuzha market and Rs. 8700 per quintal at Kozhikode market with a net gain of Rs.700 per quintal at Kochi and Alappuzha market and Rs.800 per quintal at Kozhikode market and it showed an upward trend during the month.

During the month, the price of milling copra at Kangayam market opened at Rs.7025 and closed at Rs.8000 with a net gain of Rs.975 per quintal during the month.

During the month, the price of milling copra at Kangayam market opened at Rs.7500 and closed at Rs.7100 with a net loss of Rs.400 per quintal during the month.

Weekly price of Milling Copra at major markets (Rs/Quintal)				
	Kochi	Alappuzha (Rasi Copra)	Kozhikode	Kangayam
01.07.2023	7800	7650	7900	7025
08.07.2023	7800	7550	7800	7050
15.07.2023	7900	7650	7900	7275
22.07.2023	8200	7950	8300	7650
29.07.2023	8400	8250	8550	7900
31.07.2023	8500	8350	8700	8000

Edible copra

During the month the price of Rajpur copra at Kozhikode market opened at Rs. 8000 per quintal expressed an upward trend during the month and closed at Rs. 9100 per quintal with a net gain of Rs. 1100 per quintal.

Weekly price of edible copra at Kozhikode market (Rs/Quintal)	
01.07.2023	8000
08.07.2023	7900
15.07.2023	8300
22.07.2023	8400
29.07.2023	9000
31.07.2023	9100

Ball copra

The price of ball copra at Tiptur market opened at Rs. 7700 per quintal and closed at Rs.9200 per quintal with a net gain of Rs. 1500 per quintal.

Weekly price of Ball copra at major markets in Karnataka (Rs/Quintal) (Sorce: Krishimarata vahini)	
01.07.2023	7700
08.07.2023	8000
15.07.2023	8900
22.07.2023	8400
29.07.2023	9800
31.07.2023	9200

*NR-Not reported

Dry coconut

At Kozhikode market, the price of dry coconut opened at Rs. 9500 per quintal and closed at the same price during the month.

Weekly price of Dry Coconut at Kozhikode market (Rs/Quintal)	
01.07.2023	9500
08.07.2023	9500
15.07.2023	9500
22.07.2023	9500
29.07.2023	9500
31.07.2023	9500

Coconut

At Nedumangad market in Kerala, the price of coconut opened at Rs. 14000 per thousand nuts and closed at Rs. 13000 per thousand nuts with a net loss of Rs. 1000 per thousand nuts during the month.

At Pollachi market in Tamilnadu, the price of coconut opened Rs. 19000 per ton and closed at Rs. 22500 per ton with a net gain of Rs.3500 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. 22000 per ton and closed at Rs. 32000 per ton with a net gain of Rs.10000 during the month.

Weekly price of coconut at major markets				
	Nedu-mangad (Rs./1000 coconuts)#	Pollachi (Rs./MT) ##	Bangalore Grade-1 coco-nut,(Rs./ 1000 coconuts) ##	Mangalore Black coconut (1 tonne) ##
01.07.2023	14000	19000	20000	22000
08.07.2023	14000	19000	20000	20000
15.07.2023	13000	19500	20000	24000
22.07.2023	13000	21500	20000	30000
29.07.2023	13000	22000	20000	32000
31.07.2023	13000	22500	20000	32000

International price

Coconut

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

Weekly price of dehusked coconut with water				
Date	Domestic Price (US$/MT)			
	Philippines	Indonesia	Srilanka	India*
01.07.2023	120	140	199	231
08.07.2023	121	139	189	231
15.07.2023	120	147	196	237
22.07.2023	121	146	207	261
29.07.2023	122	140	208	268
				*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)	Philip-pines	Indo-nesia	Sri lanka	India*
01.07.2023	1000	NR	NR	1964	1224
08.07.2023	1050	NR	NR	1790	1232
15.07.2023	1060	NR	NR	1833	1265
22.07.2023	1056	NR	NR	1753	1329
29.07.2023	1070	NR	NR	1776	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
01.07.2023	627	592	1120	854
08.07.2023	636	582	1055	857
15.07.2023	643	588	987	885
22.07.2023	649	595	938	930
29.07.2023	654	601	1002	961
				* Kangayam

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

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August 2023
Vol. LXVI No.02
Price: Rs.6

Registered No.KL/EKM/721/2021-23
Licence No. KL/CR/EKM/WPP-18/2021-23
Licensed to Post Without Prepayment
RNI No. 3032/1957

INDIAN COCONUT JOURNAL
Date of Publication - 24/8/2023

Printed and Published by Mini Mathew on behalf of Coconut Development Board, Printed at M/s KBPS, Kakkanad, Kochi-30
and Published at Coconut Development Board, Govt. of India,
Ministry of Agriculture and Farmer's Welfare, Kera Bhavan, Kochi-11, Editor: Deepthi Nair S