Surekha*, Bhavishya, Subramanian P, Ravi Bhat and S Elain Apshara

Adoption of advanced agro-technologies: A harbinger of enhanced income from Coconut, Arecanut and Cocoa farming

Coconut, arecanut and cocoa are an important plantation crops which are a livelihood option for a substantial number of farm families in India. Farmers could increase their net income significantly by adopting the advanced agro-technologies. This article provides a glimpse of these technologies that could enhance farm income by reducing the cost involved in the production systems or improving the yield.

THE rigorous scientific research conducted over the years at ICAR-Central Plantation Crops Research Institute has resulted in many improved crop production technologies successfully demonstrated in farmer's fields. Such improved production technology for enhancing yield of coconut, arecanut and cocoa are given below.

COCONUT

High-quality planting materials

Coconut is a perennial crop; hence, it takes 4-5 years after planting, before it flowers and produces economic yield. Therefore, the selection of quality planting material is a key ingredient for establishing a successful coconut orchard. In tall coconut varieties, preference should be given to vigorous one-year-old seedlings, characterized by more than 100 cm height with 5-6 leaves and a girth of 10 cm at the collar while planting. In dwarf varieties, the girth and height of good quality seedlings should be more than 8 cm and 80 cm, respectively. Another important trait of coconut that is preferred while choosing healthy seedlings is early leaf splitting. In general, one-year-old seedlings are preferred for planting. However, in water-logged areas, 1½ to 2 years old seedlings are found to be suitable.

Polybag-raised seedlings are advantageous as the entire ball of earth with the root system is placed in the pits. The seedlings establish early and more vigorously, avoiding any transplanting shock.

Site selection

Soils with a minimum depth of 1.2 m and good water holding capacity are preferred. Low-lying areas vulnerable to water stagnation, clayey soil with poor drainage and shallow soils with underlying hard rock sites should be avoided.

Optimum spacing and ideal planting geometry

An optimum plant density has to be maintained. In general, a square system of 7.5 m × 7.5 m (175 palms/ha) to 8.0 m × 8.0 m (156 palms/ha) is recommended. An additional 25 palms can be planted if the triangle technique is used. A hedge system can also be followed, providing 9.5 m × 6.5 m of spacing (170 palms/ha). A wider spacing of 10 m × 10 m is recommended to facilitate multiple cropping in coconut gardens to accommodate several annual and perennial crops in the interspaces.

Planting of coconut seedling

Optimum pit size and appropriate method for planting

The size of pits will depend upon the type of soil. In case of laterite soil with rocky substratum, deeper and wider pits, 1.5 m length × 1.5 m breadth × 1.2 m depth, may be dug and filled with loose soil, powdered cow dung and ash up to a depth of 60 cm before planting. Adding 2 kg of common salt to such soils is recommended to loosen the soil. To conserve soil moisture, 25-30 coconut husks/pit can be buried at the bottom of the pits. In normal soils, a pit size of 1 m × 1 m × 1 m is generally recommended. In coastal sandy soils, the pit of dimension 0.75 m × 0.75 m × 0.75 m is made for planting. These pits are filled to a height of 60 cm below ground level with a mixture of top soil and FYM or any compost, and at least two layers of coconut husk (with the concave surface facing up) can be arranged at the bottom of the pit before filling up the pit. This ensures moisture conservation. In areas with littoral sandy soils, the application of 0.15 m^3 red earth is recommended to improve the physical condition of the soil. In water-logged soils, mounds are made, and seedlings are planted in the centre of the mound.

Planting in the right season

In well-drained soils, seedlings can be transplanted with the onset of south-west monsoon during June or with the onset of north-east monsoon during October-November. In low-lying areas subject to inundation during monsoon periods, it is preferable to plant the seedlings after the cessation of the monsoon.

Proper care for juvenile palms

Young palms should be given proper care during their early years of growth to realize a high yield. After field planting, staking has to be done to protect the seedlings from the heavy winds; during summer, seedlings should be shaded with plaited coconut leaves or any other suitable shading materials to protect them from bright sunlight and irrigate adequately @ 45 litres once in 4 days in all soil types. For drip irrigation, daily 10 litres of water needs to be provided. In water logging-prone areas, the provision of proper drainage is crucial. Periodically, weeds from the pits need to be removed, and the soil covering the collar region of the seedlings during the rainy days should be removed. Every year, before applying manure, pits should be widened and gradually filled up as the seedlings grow. By the fourth year, the basin should be fully prepared to a radius of 1.8 m from the trunk. The palms should be frequently examined for pest and disease incidence, and necessary remedial measures should be taken up.

Manuring

Regular manuring right from the first year of planting is vital for good vegetative growth, early flowering and bearing and high yield. It is recommended to test soil in the coconut garden (once in 3 years), and the type and dosage of chemical fertilizers are recommended.

The first dose of fertilizer is applied three months after planting, and the nutrient recommendations of ICAR-CPCRI should be followed (Table 1). During the first year, the quantity of fertilizer to be applied is approximately one-tenth of the recommended dose for adult palms.

During the second year, one-third of the dosage recommended for adult palms should be applied, and the dosage should be doubled in the third year. From the fourth year onwards, fertilizers may be applied at the rate recommended for adult palms. The fertilizer should be applied in two splits, one-third of the recommended dose is applied after the receipt of summer showers around the palms within a radius of 1.8 m and forked in. Circular basins of 1.8 in radius and 25 cm depth are dug during August-September, and green leaf or compost at the rate of 50 kg/palm is spread in the basin. Two-thirds of the recommended fertilizer dose is applied over the green leaf or compost and covered with soil. Among micronutrients, boron deficiency is commonly noticed in many areas, and the application of 120 g Borax/palm in four equal splits is based on the intensity of deficiency symptoms. Besides the above fertilizers dose, one kg of finely ground dolomite or limestone and 0.5 kg of magnesium sulphate should be applied per palm/year and is recommended for acidic soils as well as light sandy soils. The dolomite/lime may be applied before the commencement of monsoon rains in the coconut basins and forked in.

Organic manures in palm nutrition

The combined application of organic and inorganic fertilizers is very beneficial. Organic farming approaches, including organic manure (green leaf manuring, cattle/goat/poultry manure), basin management through cover-cropping (*Pueraria phaseoloides*, *Mimosa invisia*, *Calopogonium mucunoides* and *Vigna unguiculata*), application of biofertilizers ('Kera Probio', 'KerAM' @ 100 g/palm/year), *Gliricidia* alley cropping and recycling of organic biomass generated through vermicomposting, coir pith compost, have substantially improved both the soil health and the capacity of the coconut palms to withstand adverse effects of climatic conditions. It is recommended to apply 10 kg/palm organic manure as compost/vermicompost/farmyard manure six months after planting in the main

Table 1. General fertilizer recommendation for coconut (g/palm)

Age of coconut palm	May-June			September-October		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
First year	Planting in May-June			50	40	135
Second year	50	40	135	110	80	270
Third year	110	80	270	220	160	540
Fourth year onwards	170	120	400	330	200	800

field. It is gradually increased at the rate of 10 kg every subsequent year till 4 years, and from the fifth year onwards, the dose may be fixed as 50 kg/palm/ year. The addition of organic manure *in situ* results in improved available nutrients build-up of organic carbon in the soil, enhancing nutrient uptake and improving palm health.

Fertigation–An efficient method of fertilizer and water application

Wherever drip irrigation is available, it is possible to use soluble fertilizers like urea, diammonium phosphate, phosphoric acid (commercial grade) and muriate of potash in six equal split doses. It is more suitable and economical as fertilizers are applied uniformly to the wetted root zone. It remarkably improves the efficiency of fertilizer application. It not only reduces the production costs but also lessens the potential of groundwater pollution caused due to fertilizer leaching. In fertigation, it is recommended to provide 91 g urea, 33 ml phosphoric acid and 170 g muriate of potash per palm/application. When DAP is used, it is recommended to provide 70 g urea, 60 g DAP and 170 g muriate of potash for a single dose per palm.

Irrigation management

Flooding, basin, sprinkler or perfo-sprays and drip irrigation are commonly adopted methods in coconut gardens.

Flood irrigation (@50,000 to 75,000 L once a week) results in a great wastage of irrigation water and poor aeration, especially in clayey soils, leading to water stagnation. Therefore, flood irrigation is unsuitable for coconut and, if possible, could be avoided. In basin irrigation (@200 L of water once in four days), water is provided in the basins of coconut through irrigation channels. Main irrigation channels are made between the two rows, and sub-channels are prepared to connect each basin. It also causes minor water losses through deep percolation, seepage and evaporation. However, this loss will be minimised if the basins are irrigated with hose pipes.

For inter or mixed cropping systems where the entire surface requires wetting, sprinkler or perfo-irrigation with 20 mm water is preferred. However, the initial investment is high, and there is a possibility of clogging the small pores when the irrigation water is not clear. Drip irrigation is ideally suited for widely spaced crops like coconut as it saves water, energy and labour with higher WUE. The irrigation efficiency of drip irrigation is 40-60% higher than palms receiving basin irrigation. The adequate yield of coconut could be achieved with drip irrigation daily @ 66% of open pan evaporation (Eo) from December to May (32 litres/palm/day). The number of dripping points should be six for sandy soils and four for the other soil types. The water application rate should be 2-3 L/hour/ emitter. Studies on the effect of mulches and irrigation on young coconut plants in coastal Karnataka indicated better growth under drip irrigation and coir pith mulch.

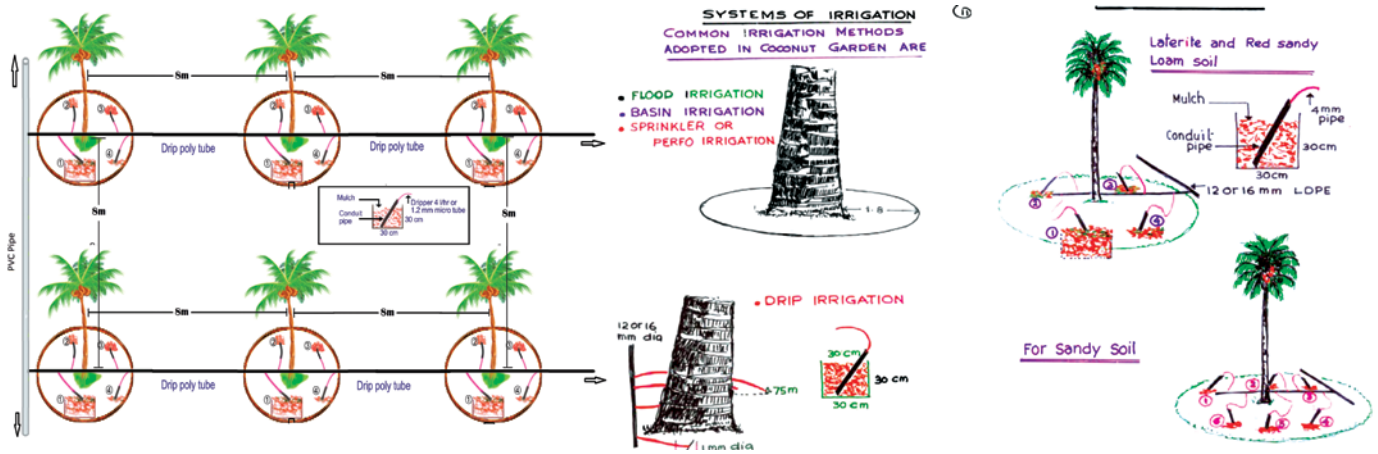
Efficient resource utilization

The low income from coconut monoculture and fluctuating market prices of coconut warrant efficient use of land and other resources. Utilizing the underutilized soil space and solar radiation in pure stands, various crops having different stature, canopy shape and size, and rooting habit can be inter-planted to form compatible combinations.

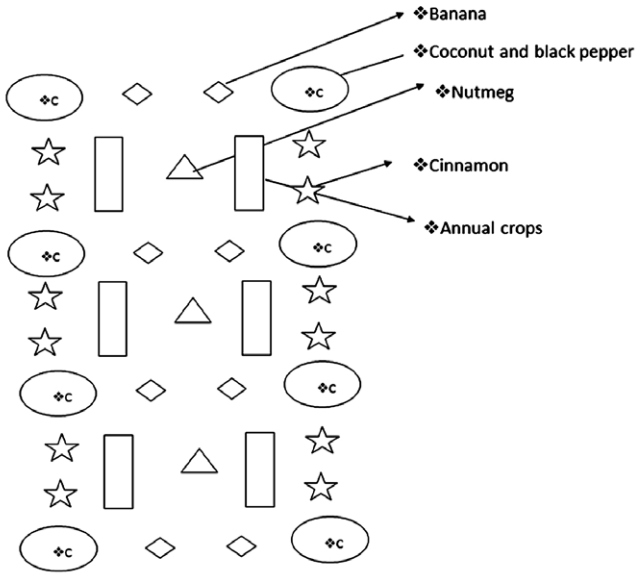
The pioneering efforts of ICAR-CPCRI have resulted in technologies for coconut based inter/mixed, multi-storied multi-species cropping systems, and the farmers are widely adopting these technologies. The high-density multi-species cropping system (involving annuals/biennials/perennials grown in different tiers) and coconut-based mixed farming system (including coconut, fodder grass, dairy, goat unit, poultry, pisciculture, etc.) that exploit soil and air space more efficiently and recycle helps to achieve maximum profits and can even buffer the price crash of the main crop. The crops selected for a cropping system should be compatible with the main crop and have local demand.

Need-based soil and moisture conservation measures in coconut

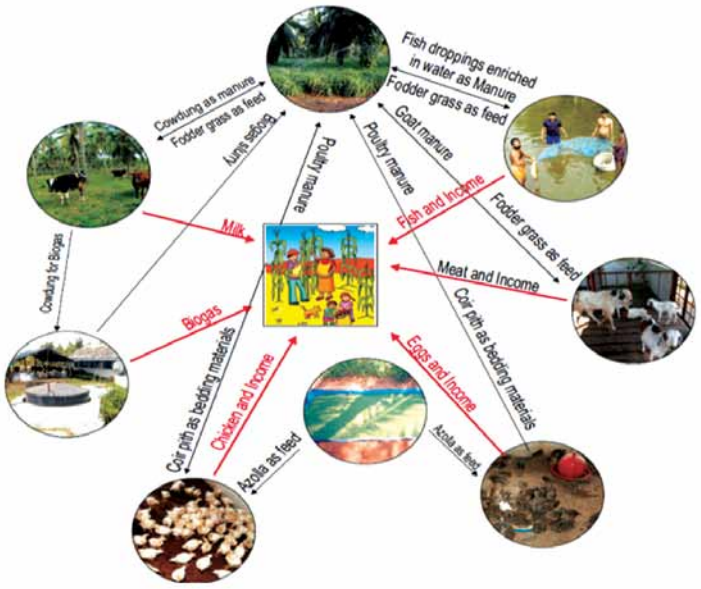
To conserve soil moisture in the coconut plantation, mulching with organic materials, viz. coconut leaves (in two to three layers), husk (in two to three layers- 250 to 300 husks/basin) and coir pith (10 cm thickness-approx. 50 kg/palm) could be practiced which helps to reduce soil temperature and evaporation from the soil surface and



Drip irrigation in coconut



Coconut based HDMSCS schematic layout



Coconut based farming system

create conditions for proper root growth and proliferation of soil flora and fauna. The best time for mulching is before the end of the monsoon and before the top soil dries up. Coconut husk burial in layers with the bottom layers facing up and top layer facing down, in the trenches (50 cm width × 50 cm depth and convenient length) dug out in the interspace of coconut will also help in soil moisture conservation.

A half-moon bund around the coconut basin reinforced with two rows of pineapple can also be taken up where there is a mild slope (15-20%) of land. The bund prevents run-off; water gets collected within the basin and percolates down. Pineapple would help protect the bund, stabilize it, and provide fruits.

If the land is highly sloped, then trenches of 50 cm width × 50 cm depth and convenient length would be made between two rows of coconut palms and filled with coconut husk, and bunds should be stabilized with crops like pineapple. One can go for catch pits also. Though there is no standard dimension for catch pits, we may go for catch pits of 1.5 m length × 0.5 m width × 0.5 m depth with a bund downstream. This pit also may or may not be filled with coconut husk.

Economic advantage

By following the above mentioned coconut cultivation agro-techniques, besides efficient utilization and conservation of natural resources, higher net returns can be realized and thereby, the economic viability of the system can be achieved. From the study at ICAR-CPCRI, Kasaragod, it was found that a coconut based farming system comprising coconut, pepper trailing on the coconut trunk, banana in the border of the plots, fodder grass (hybrid Bajra Napier Co 5) in the interspaces of coconut, and animal components (dairy, goat and poultry) generated a net return of ₹653,853/ha in 2020 and coconut based HDMSCS (involving coconut, pepper, banana, nutmeg and cinnamon) recorded 3.45 times high net returns over mono-cropping.

ARECANUT

Quality planting material: Being a perennial and cross-pollinated crop, adequate care should be taken while selecting the planting material. About 12-18 months old seedlings with more than five leaves and minimum height should be used for transplanting.

Maintain optimum population with required spacing: The optimum spacing recommended for arecanut is 2.7 m × 2.7 m. However, for accommodating high-value inter/mixed crops, spacing of 3.3 m × 3.3 m is advisable. The rows may be aligned in a north-south direction by deflecting the north-south line at an angle of 35° towards the west to minimize sun scorching.

Planting time: Planting time depends on the intensity of rains and the water table. In river banks where there is likely danger of inundation and in areas with a high water table, it is advisable to plant arecanut seedlings in the month of September. In other places, planting can be done during May-June.

Pits of optimum size and right planting method: A pit of 90 cm^3 is recommended for planting in laterite soil, whereas 75 cm^3 is sufficient in red soil. However, a pit size of 60 cm^3 is recommended when the water table is high. Pits should be filled with topsoil and farmyard manure up to half of the pit. Seedlings should be planted at the centre of the pit with a ball of earth and covered with soil up to the collar region. Planting depth is important to avoid the growth of aerial roots above the ground.

Post-planting care: The stem breaks due to continuous exposure to scorching sun on South-West side during afternoon time, and as there is no secondary growth in monocot palm like arecanut, stem breaking occurs. Thus, shading is essential in arecanut. The shade plants like banana, red gram or ivy gourd may be planted. If it is not possible, exposure to the sun can be avoided by covering the stem using arecanut or coconut leaves or a green shade net from December-May.

Irrigation: Arecanut can't withstand drought for

(A) High yielding arecanut garden, (B) Mother palm, (C) Sowing seed nut in sand bed, (D) Seed nuts sown in polybags, (E) Arecanut seedlings in polybags

Planting arecanut seedlings

Mulching

Providing shade

(A) Sun scorched arecanut stem and (B) Covering the arecanut stem to avoid exposure to the sun

a long time, and being a perennial crop, once affected by water stress, it may require two-three years to regain the normal vigour and yield. Hence it is advised that, in the humid tropics of Kerala and Karnataka, irrigation should be given at a frequency of once in 7-8 days during November-December, once in 6 days during January-February and once in 4-5 days during March-May through basin irrigation @ 175-200 litre/palm/irrigation. Irrigation efficiency is high with drip irrigation (90-95%) compared to conventional irrigation (50-60%) and sprinkler irrigation (70%). Under drip irrigation, about 16-30 litres of water is required per palm per day based on the evaporation rate. Microtubes / drippers (2-3 nos.) should be placed in the basin opposite to each other or in a triangle.

Table 2. Nutrient recommendation for arecanut (g/palm/year)

Fertilizer	First year	Second year	Third year onwards
Nutrient			
Nitrogen (N)	33	66	100
Phosphorous (P_2O_5)	13	26	40
Potassium (K_2O)	46	92	140
Fertilizers (Source of Phosphorus is rock phosphate or single super phosphate)			
Urea	72	144	220
Rock phosphate (RP)	65	130	200
Single super phosphate (SSP)	83	167	250
Muriate of Potash (MOP)	77	154	235
Fertilizers (Source of phosphorus is Diammonium Phosphate (DAP))			
Urea	61	121	182
DAP	29	58	87
Muriate of potash	77	154	235

Basin opening

Manure/Fertilizer application

Covering with soil

Manure/Fertilizer application in the arecanut basin

Nutrition schedule: Applying only organics or chemical fertilizer may lead to a nutrient imbalance in arecanut. Thus, nutrient management strategies need to be planned for arecanut considering the soil fertility status with the help of plant and soil analysis (Table 1).

In laterite soils, application of 100 g N, 40 g P_2O_5 and 140 g K_2O is recommended as a general dose of fertilizer every year. In addition, the application of 12 kg each of green leaf and compost/palm is also recommended. In heavy soils, the general recommendation of nutrients is 50 g N, 40 g P_2O_5 and 140 g K_2O, along with green manures.

Fertilizers and organic manures should be applied when the soil has sufficient moisture but not during heavy rainfall and dry periods. If the soil *p*H is less than 5, lime (preferably dolomite lime) should be applied during August-September. The first dose of fertilizer (50% of RDF, i.e. 50 g N, 20 g P and 70 g K) can be applied at a distance of 50-60 cm along with organic manures (12 kg FYM and 12 kg green leaf manure) during September-October in basins around the palm. The same quantity of fertilizer without organic manure should be applied during February-March and mixed with the soil by forking. In soils with acidic *p*H (below 6.0), the fertilizer may be applied as urea, rock phosphate and muriate potash. DAP can be used as a P source in 6.0-7.0 *p*H soil, whereas SSP can be used in alkaline soil.

Organic manure alone cannot meet the K demand of arecanut as organic manures contain less K, except husks of arecanut, coconut and cocoa. For high-yielding arecanut palms with kernel or *chali* yield more than 3 kg/palm/year, a double dose of fertilizers, especially N and K can be applied.

Drip-fertigation for efficient resource utilization: This technology can be profitably adopted in arecanut, saving up to 25-50% fertilizer. Easily available fertilizers like urea, diammonium phosphate (DAP) and potassium chloride (MOP) are water-soluble (90-100%) and are cost-effective sources of NPK. Liquid fertilizers are readily soluble in water. However, they are costly and can be used for fertigation. Fertilizers should be applied during the post-monsoon season from December to May, coinciding with flowering, fruit set and fruit development. The total quantity of fertilizer can be split into 9 or 18 parts, and each part can be applied once in 20 or 10 days, respectively. For pre-bearing palms, 50% of recommended fertilizer is adequate when supplied through the drip, whereas for bearing palms, 75% of the recommended fertilizer dose is sufficient. The quantity of nutrients to be given through fertigation is 75:30:105 g N, P_2O_5, and K_2O per palm per year. The quantity of fertilizer required to supply the recommended dose per palm per year is 136 g Urea, 65 g DAP and 175 g MOP.

Adequate drainage: For adequate drainage, provide drainage channels in the garden, and the number of channels depends upon the soil types, viz. one in two rows in light soils and each row when soil is heavy and the channel should be at least 15-30 cm deeper than the depth at which the seedlings are planted. At the beginning of the monsoon, these drains are to be cleaned to have an easy flow of water. Even the planted pits should be

(A) Crown choking and crown bending due to zinc deficiency; (B) nut splitting due to boron deficiency; (C) leaf tip necrosis due to potassium deficiency

Arecanut + Black pepper

Arecanut + Vanilla

Arecanut + Black pepper + Coffee

Arecanut + Lemongrass

Arecanut + Periwinkle

Arecanut + Brahmi

Arecanut based multispecies cropping system

Arecanut based cropping systems

provided with outlets and linked to drains.

Intercultural operations: Weeding should be done as and when required, and the collected weeds can also be recycled in areca basins. The glyphosate can be sprayed to control weeds in interspaces and not in crop basins. Terracing and contour bunding measures should be adopted in undulating lands to prevent soil erosion. In *Malnad* tracts, the main purpose of the intercultural operation is to loosen the soil and rebuild the soil fertility after the heavy rains during the monsoon. In the *Maidan* region, it is to conserve the soil moisture and prevent the hardening of the heavy soils. Sowing of cover crops like *Mimosa invisa* (@15 kg/ha), *Stylosanthes gracilis* (9 kg/ha), *Calapogoniumm uconoides* (@11 kg/ha) and *Pueraria javanica* (@ 11 kg/ha) can be taken up during May-June which can be cut and incorporated during October.

Arecanut-based cropping/farming system for income and efficient utilization of resources: The long pre-bearing period, low returns during the initial bearing stage, fluctuations in market prices, unexpected loss due to pests and diseases and natural calamities are the main reasons which make inter-cropping or mixed farming in arecanut plantation essential. Crops like banana, pepper, cocoa, elephant foot yam, citrus, betel vine, pineapple, etc. are suitable for mixed cropping. As the age of the garden advances, only a few crops, viz. pepper, cocoa, banana, lime, nutmeg and betel vine, can be grown profitably as mixed crops. It is advisable to grow various medicinal and aromatic plants in small and large areas based on local demand, which helps achieve increased net income per unit area and unit time.

High density multispecies cropping system (HDMSCS): Some of the HDMSCS models suggested in arecanut gardens are given in Table 2.

Table 3. Region-specific cropping models

Region	Cropping model
Maidan parts of Karnataka	Arecanut + banana + acid lime Arecanut + black pepper + cocoa
Coastal Karnataka and Kerala	Arecanut + black pepper + cocoa + banana
North Bengal	Arecanut + black pepper + banana Arecanut + black pepper + acid lime
Wynad of Kerala	Arecanut + cardamom
Hilly zone/ *Malnad* region of Karnataka	Arecanut + cardamom Arecanut + black pepper + cocoa Arecanut + black pepper + coffee

Arecanut-based mixed farming: It is advised that for profitable dairy management, a minimum of four cows (preferably different breeds like Holstein Friesian, Jersey, Gir and local) should be maintained so that 2-3 animals can yield milk throughout the year. It is also recommended to use arecanut leaf sheath as cattle feed with 10% supplementation, reducing feed cost by ₹1.5/kg mix.

COCOA

Quality planting materials: When cocoa seedlings are used for planting, only vigorous and healthy seedlings produced from polyclonal seed gardens or selected mother plants should be selected. When budded plants are used, selecting two or more clones for planting is advised to avoid self-incompatibility induced production issues.

Suitable site: The ideal soil type recommended for cocoa should have 1.5 m depth, 3.5% organic matter, >9 C/N ratio, >12 meq per 100 g soil base exchange capacity and >35% base saturation. In India, it can be grown mostly in laterite soils, whereas black and alluvial

Potting mixture preparation

Sowing seeds

Cocoa seedlings

soils are also suitable. As it is a shade-loving crop, it is desirable that arecanut, coconut or oil palm plantation, which will let in more light through the canopy, may be chosen for raising cocoa.

Cocoa grows both under temporary and permanent shade trees. In the case of temporary shades, once the cocoa canopy develops, they are removed to increase the light transmission. Plantain, Tapioca, *Gliricidia*, *Xanthosoma* spp., *Colocasia* spp., Tree cassava or Ceara rubber (*Manihot glazovii*), Pigeon pea (*Cajanus cajan*), Papaya (*Carica papaya*) and Castor (*Ricinus communis*) are being used as temporary shades in different countries. Over 100 species of permanent shade trees are used for cocoa. *Erythrina* spp., *Leucaena leucocephala*, *Cordia alliodora*, *Tabebuia rosea, Cedrela odorata, Cola nitida, Myristica fragrans, Gliricidia sepium, Albizzia falcataria, A. chinensis* and *Parkia javanica* are used as permanent shade trees. Hills and valleys of Kerala and Karnataka with available permanent shade trees can be utilized for rejuvenation of traditional belts

Optimum spacing: The optimum spacing recommended for cocoa is 2.7 m × 5.4 m spacing in an arecanut garden spaced at 2.7 m × 2.7 m. Under coconut palms planted at 7.5 m × 7.5 m spacing, cocoa can be planted in the centre of two rows of coconut at 2.7 to 3 m spacing in a single hedge system with a population density of 444 trees/ha. When the spacing of coconut is more, a double hedge of cocoa with 2.5 to 2.7 m is advised with a population density of 800 trees/ha. In oil palm gardens of 9.9 or 10.5 m triangular plantings, cocoa should be grown at 2.4 m spacing. Cocoa should be 2 m away from the base of the palm. Shade in oil palm plantations is very high; hence the age of the palms, square plantings of oil palm and wider spacing can be considered.

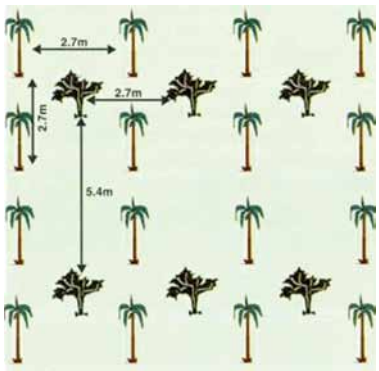
Optimum pit size: A pit of 50 cm^3 is recommended for cocoa planting, and it should be filled with a mixture of topsoil and organic manure, and a seedling is planted in the centre. The main purpose of the digging pit is to break the hard pan in the sub-surface and loosen the soil in the root rhizosphere for better root growth.

Planting season and planting method: In low rainfall areas, the planting can be done at the onset of the monsoon, whereas, in areas of high rainfall, the planting can be done at the end of the monsoon. If the moisture can be maintained by irrigation, planting can be done at any time of the year.

Ensure irrigation for good growth and yield of cocoa: It is known that cocoa plants require continuous moisture supply for optimum growth and yield; hence, ensuring adequate irrigation is very important for cocoa both in mono-cropping and mixed cropping systems. With flood/furrow irrigation, trees should be irrigated once in five days with 175 litres of water, and through drip irrigation, 20 liters of water/day/ tree. During summer, irrigation at weekly intervals is advised in cocoa cultivation, which coincides with flowering, fruit set and cherelle/pod development.

Table 4. Recommended fertilizer for cocoa

Fertilizer	I year	II year	III year onwards
Nitrogen	33	66	100
Phosphorous	13	26	40
Potash	46	92	140
Urea	72	144	220
Rock phosphate	65	130	200
Muriate of Potash	77	154	230
Shallow basins	1 ft	2.5 ft	3 ft



Cocoa grown as a mixed crop with arecanut and coconut

Digging pit

Planting cocoa seedling

Shading and drip irrigation

Planting of cocoa in pits

Table 5. Application of fertilizers through drip-fertigation

Crop phase	Period	10 days interval				20 days interval			
		No. of doses	Fertilizer per dose			No. of doses	Fertilizer per dose		
			Urea (g)	DAP (g)	MOP (g)		Urea (g)	DAP (g)	MOP (g)
Flowering and fruit set	December-January	6	7.5	3.6	9.7	3	15	7.2	19.4
Cherelle development	February-March	6	7.5	3.6	9.7	3	15	7.2	19.4
Fruit development	April-May	6	7.5	3.6	9.7	3	15	7.2	19.4

Nutrition to cocoa: The recommended dose of fertilizer (Table 3) should be applied in two equal splits: the first dose in April-May and the second in September-October, i.e. pre and post-monsoon applications. The fertilizer should be applied uniformly around the base of the tree up to a radius of 30 cm (1 ft.) during the first year, forked and incorporated into the soil. For grown-up plants, the best method is to rake and mix the fertilizers with soil in shallow basins of around 75 cm (2.5 ft.). This radius may be increased gradually up to 90 cm (3 ft.) after the third year.

Fertigation method is also recommended during the post-monsoon season from December to May at an interval of 10 or 20 days (Table 4). Only 75% of the recommended fertilizer dose, i.e. 75 g N, 30 g P_2O_5 and 105 g K_2O, is sufficient to meet the nutrient demand of cocoa when it is grown as a mixed crop with arecanut. Water soluble fertilizers like Urea, Di-Ammonium Phosphate (DAP) and Potassium Chloride (MOP) are easily available and cost-effective. However, 100% water soluble fertilizers like 19.19.19, 13.0.45, 0.0.50 etc. are easy to use but costlier.

Pruning to maintain the canopy architecture: It is recommended to practice the pruning operation in cocoa, especially when it is grown as an intercrop, mainly to maintain the shape so as to keep it more productive and efficient through induction of flowering and distribution of nutrients towards developing pods. Pruning positively affects flushing, flowering and fruiting rates in cocoa. In Karnataka and Kerala, pruning is carried out in August-September.

If the cocoa tree is allowed to grow naturally, at a young age, the first jorquette will be formed at a height between 1 and 2 m and this low jorquette or low-lying branches will make it difficult to move into the garden and to carry out harvesting, spraying and any other farm operations. So, formation pruning is recommended and a jorquette at 1.5 m is optimized. This helps in training the crop to determine the shape of the tree. At the jorquette, five fan branches are normally formed, and four fan branches in all four directions will be advantageous

Deficiency symptoms of different nutrients in cocoa (A) potassium; (B) zinc; (C) iron; and (D) boron

Pruning in cocoa seedlings

in holding the tree in position, and three branches are preferred in older trees. Removal of basal chupons at regular intervals, trimming, cutting back, or removing low branches is important.

The ideal canopy architecture recommended for trees in the middle age group from 12-15 years old is a canopy spread of 3.8 to 4.0 m and a height of 2.7 m. Pruning is to be followed to retain 20-30 leaves developing per pod. Funnel-shaped architecture is also suggested in grown-up trees of seedling origin, which provides good ventilation and exposure to the sun by cutting low-hanging branches first, then chupons and branches within 60 cm from the jorquette. Top pruning to a height of 4 m is recommended to facilitate harvesting and removal of mummified pods.

Cocoa multiplied by clonal propagation using fan branches tend to give lower and multiple branching habits; hence in the first or second year of planting, primary pruning should be done to obtain a supporting framework of one upward growing main stem. Then, drooping or inward-growing branches are to be removed. After the third year, secondary pruning is suggested to develop an umbrella-shaped canopy. Chupon grafted plants will give seedling-like architecture, but fans are used in commercial nurseries since the number of fans available per tree is more.

While pruning, it is advised to maintain a minimal disturbance to the bark and plant with flowers, cherelles and young pods. After initial pruning, maintenance pruning must be followed to keep the canopy structure intact. With sufficient shade and water, slight trimming should be practiced when the climate is cool. In all pruning methodologies, all cut ends or exposed wood surfaces should be swabbed with Bordeaux paste immediately after pruning to avoid fungal infection, which is predominant in the humid environment.

Top working to rejuvenate old and unproductive cocoa trees: Care should be taken that the trees selected for top working should have a strong and healthy root and shoot system. Decapitation of shoots of old trees at a certain height shall be done, which initiates upward growing or orthotropic shoots or chupons. On these chupon, shoots budding or grafting may be practiced with bud/scion from elite clones. A technique standardized by KAU snaps back the main shoot below the jorquette or first branching after cutting halfway, which is highly skilled. The snapped canopy continues to have contact with the trunk. Many chupons will arise below the point of snapping; patch budding is done on three to four vigorous and healthy shoots using scions from high-yielding, disease-resistant clones. About 50% improved yields in the second year and 100% increase in the third year are obtained from top worked trees.

For further interaction, please write to:
Dr Surekha (Scientist), ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala 671 124. **Dr Bhavishya** (Scientist), ICAR-Central Plantation Crops Research Institute, Regional Station, Vittala, Karnataka 574 243 *Corresponding author email: surekharajkumar8@gmail.com; bhavishya@icar.gov.in

Flowers always make people better, happier, and more helpful; they are sunshine, food and medicine for the soul.

– Luther Burbank