



1 A pure stand of 30-year-old coconut palms planted at 7.5 x 7.5 m spacing

Increased production per unit area of agricultural land, time and input is achieved in the case of annuals through multiple cropping—growing a sequence of crops in quick succession in one year or other relevant time span. In plantations like coconut, where the land remains committed to the main crop for decades, the strategy for maximising production has to be different. A new concept, termed multi-storeyed cropping, has been developed and put to practice at the Central Plantation Crops Research Institute, Kasaragod.

Crops having different stature and rooting habits are grouped to form compatible combinations so as to enable interception and utilisation of light at different vertical intervals and facilitate foraging the soil at different layers and columns. One such combination is coconut + pepper + cacao/ cinnamon + pineapple. Coconut, spaced 7-5m apart and growing 10-30m tall, functions as the top floor of this crop building. The second- floor crop of pepper develops the canopy on the coconut trunk at a height of 3-8m. Cacao/cinnamon, which grows 1 -5-2-5m high, forms the first floor and pineapple, with its shallow root system, constitutes the ground floor. The authors describe such crop combinations on trial at Central Plantation Crops Research Institute, Kasaragod, S India, and analyse the factors and environments which influence and contribute to the biological, operational and economic efficiencies of such intensive cropping systems.

Multi-storeyed cropping

A NEW DIMENSION

IN MULTIPLE

CROPPING

FOR

coconut

PLANTATIONS



2 Multi-storeyed crop combination of coconut black pepper -j- cacao 4- pineapple at the experimental farm of CPCRI

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CROP PRODUCTION is really the conversion of solar energy into chemical energy of a storable, movable and economically useful form through the photosynthetic apparatus of plants. In any conversion process, 'efficiencies' are involved. In crop production, efficiency would mean the rate at which solar energy is converted into economic produce. Calculations based on theoretical concepts have shown that the potential productivity of a crop under conditions of optimum management is 770kg dry matter/ha/day, which is equivalent to an annual biological yield of 281.05 tons/ha¹. But the actual production of a coconut plantation is much below this figure. Taking an average yield of 100 coconuts per palm per year, which is considered to be a relatively good yield under the prevailing conditions in the coconut-growing belt of the west coast of India,

the total biological production is only 17.1 tons/ha/year, as given in table 1.

Table 1
Total annual biological production of a coconut plantation per hectare*

Plant part	Dry weight/ha/year (tons)
Whole nut	11-10
Spathes and spadices	1-15
Leaves	4-32
Stem	0-53
Total	17-10

*Average yield of 100 nuts/palm/year, 175 palms/ha, and 13 leaves/palm/year.

This low level of productivity could be attributed partly to the non-utilisation of available resources to the fullest extent possible. According to the bio-energetic concept of crop production, the major environmental resources in the process of crop production are solar energy and land surface. Advances in agricultural technology have paved the way to increase the productivity, most significant among them suitable for the tropics being the technique of multiple cropping, which keeps the photosynthetic factory operative at higher efficiency for longer duration within a calendar year or other relevant time span.

The philosophy of multiple cropping is one of maximum crop production per unit time and area of land, with minimum of soil deterioration⁵. In the case of annuals, this could be attained by growing crops in sequential or relay combinations. In perennial crops like coconut, where the land remains committed to the same crop for a number of years, the strategy has to be different. Here the aim should be to raise a combination of crops or crop mix whose mutual compatibility enables more efficient utilisation of the resources like sunlight, soil and water.

Table 2
Pattern of land utilisation by a pure stand of coconut palms

Land area available for a single coconut palm, planted at 7.5 x 7.5m spacing	56-25m ²
Area of maximum concentration of coconut roots (7r ²) r = lateral spread = 2m	12-57m ²
Percentage of total area effectively utilised by coconut roots $\frac{12.57}{56.25} \times 100$	- 22.24

For a scientific development and evaluation of such a technique, it is essential that the pattern of utilisation of the natural resources in a pure stand of coconut, is characterised.

1. Land utilisation

Studies conducted at Central Plantation Crops Research Institute (CPCRI), Kasaragod, have shown that the effective root zone of an adult bearing coconut palm growing under normal management is confined laterally within a radius of 2m around the base of the palm³. Studies on the vertical distribution of roots have shown that the top 30cm layer soil was practically devoid of functioning roots and that about 86% of the roots were found between 30 and 120cm depth from the surface¹. However, the morphological features of the coconut palm necessitates its planting at 7.5 x 7.5m spacing (fig 1). These observations indicate that 77.7% of the total available land area in a pure stand of coconut is not effectively utilised by the coconut roots (table 2).

2. Solar energy utilisation

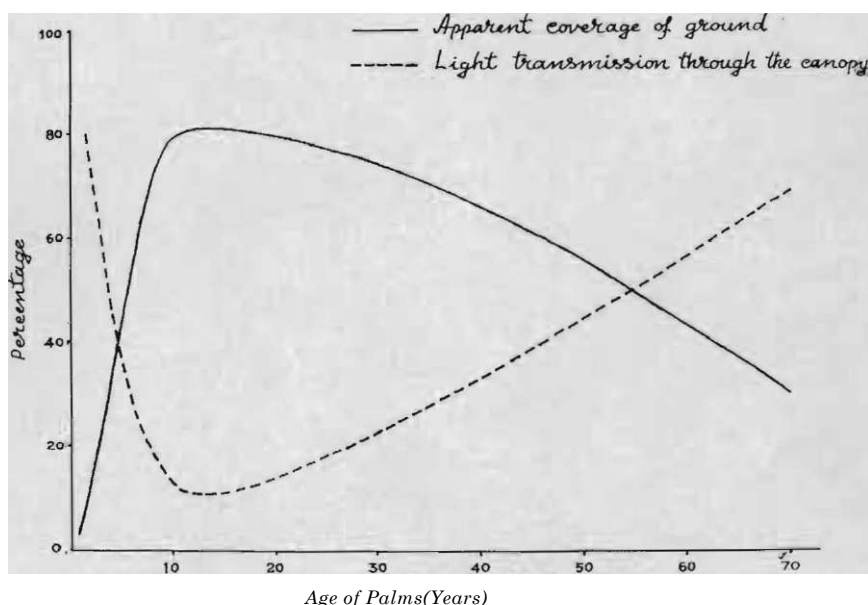
(i) CANOPY DEVELOPMENT: Fig 3 shows the pattern of changes in the apparent coverage of ground by coconut canopy with respect to age of the palms. After attaining maturity, there is little change in the spread of the coconut crown, although a slight reduction in the size of

the fronds may occur. Yet the canopy-coverage of ground progressively decreases with the increase in height and the resultant increase in the amount of sunlight from the slant rays, (ii) DISTRIBUTION OF LIGHT PROFILE: THE Venetian structure and the orientation of coconut leaves permit part of the solar radiation incident on the foliage to percolate to lower profiles and ground surface. The extent of this transmission varies with age of palm and is almost inversely related to apparent, ground coverage by the crown, as depicted in fig 3.

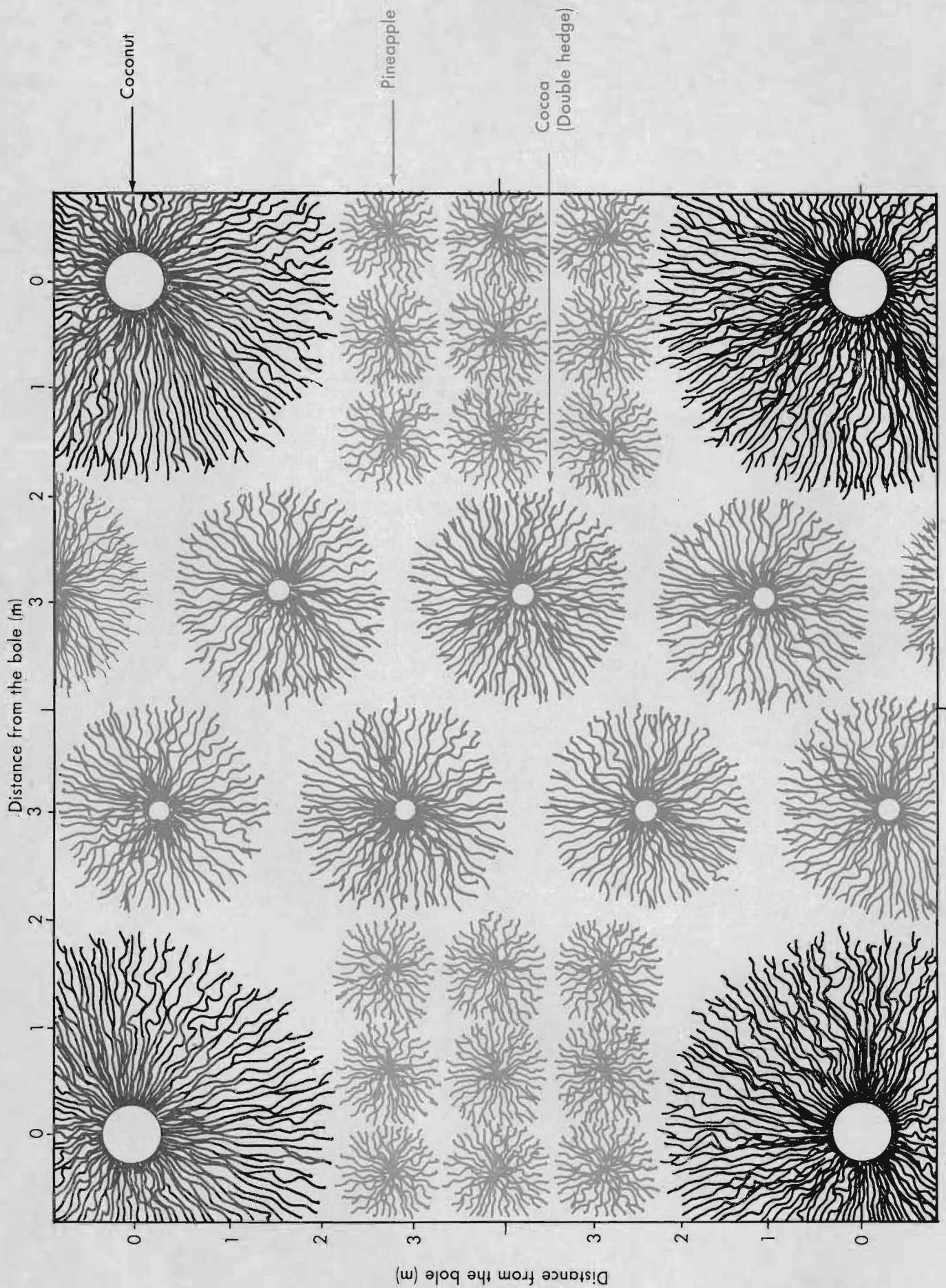
The above analyses of the characteristic features of coconut palm suggest the possibility of intensifying the cropping in the interspaces by introducing- parallel combinations of compatible crops. Essentially, the crops that could be meshed into mutually compatible combinations should have varying nutritional and environmental requirements and morphological and physiological features. In addition, the subsidiary crops should be relatively shade tolerant.

Intercropping

When annuals or seasonal crops are grown in the interspaces it is designated as intercropping. A number of such crops have been tried at CPCRI, Kasaragod. These included tuber crops like elephant foot yam (*Amorphophallus companulatus*), cassava or tapioca (*Manihot utilissima*), sweet potato (*Ipo-moea batatas*), ginger (*Zingiber officinale*) and turmeric (*Curcuma lortga*), cereals like dry paddy, and pulses like green gram (*Phaseolus aureus*), black gram (*Phaseolus mango*) and horse gram (*Dolichos bijlorus*). Growing such intercrops, apart from being remunerative, had no adverse effect on the growth and yield of coconut when both main crop and inter-crop were adequately and separately manured. Trials on the feasibility of raising an array of other intercrops are also on the way.

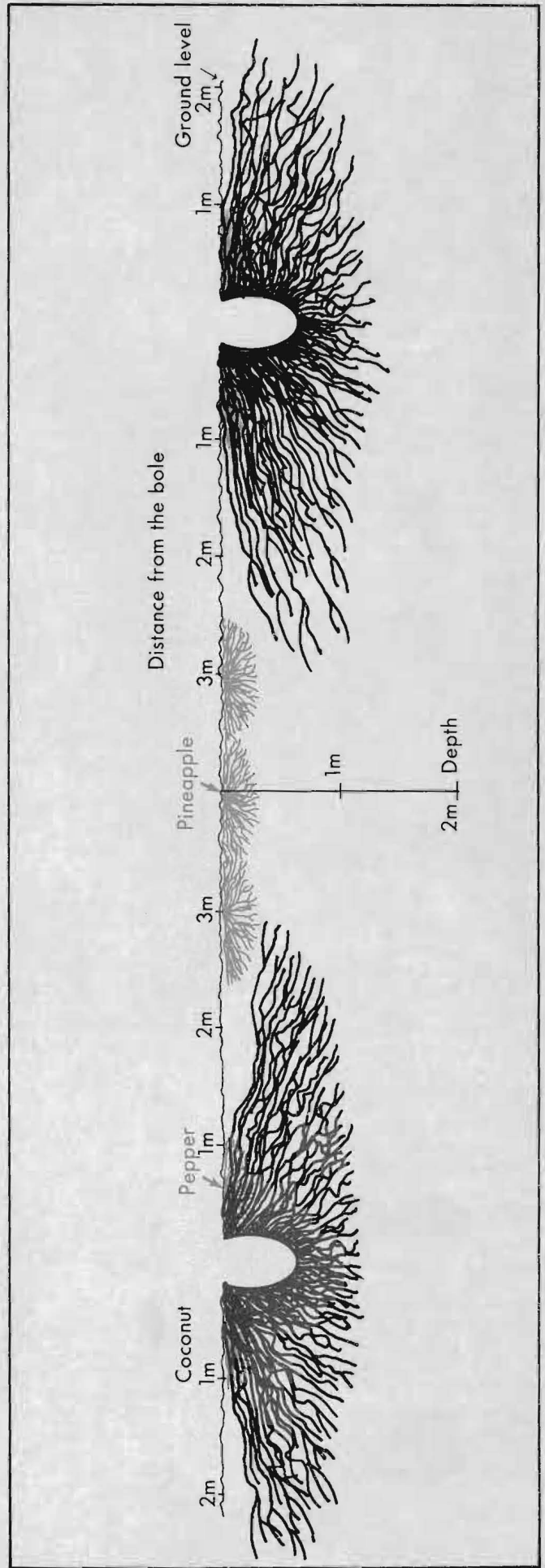
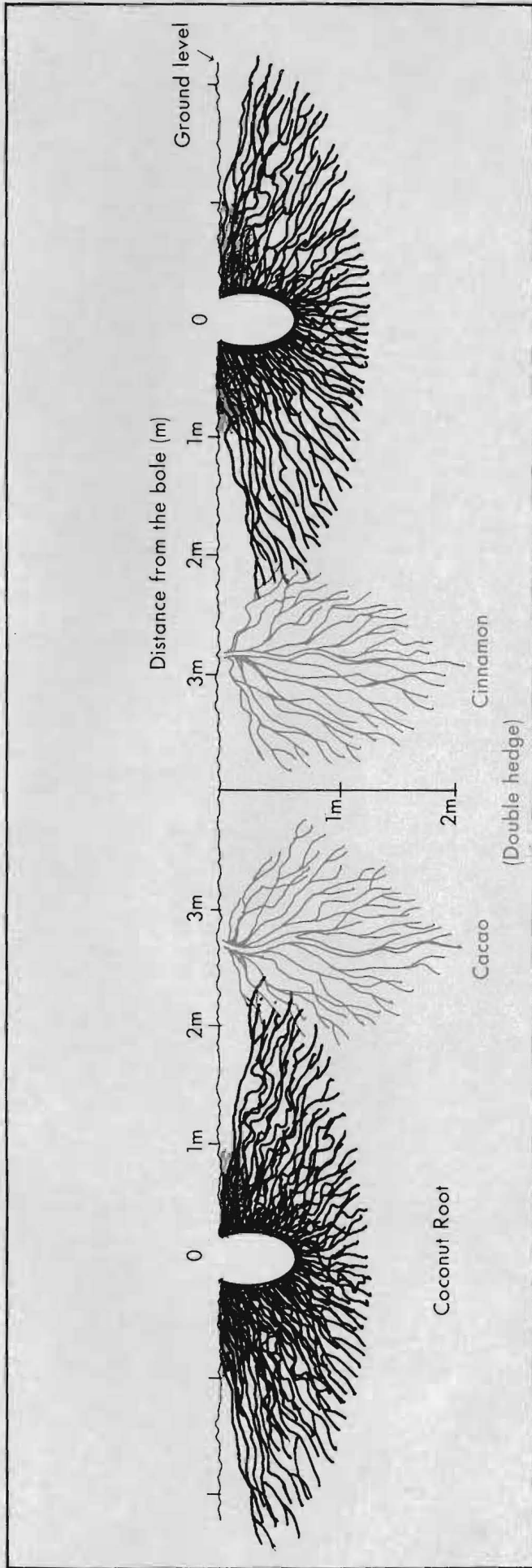


3 Apparent coverage of ground by coconut canopies of various age groups



4 Schematic representation of pattern of horizontal root distribution of the multi-storied crop combination

5 Schematic representation of pattern of vertical root distribution of the multi-storied crop combination



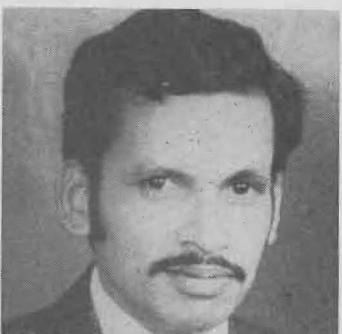


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After a year of post-doctoral research associateship at the Rothamsted Experimental Station, England, Dr Nair joined the CPCRI as agronomist in 1972. He is particularly interested in multiple cropping.



Mixed cropping

When perennials are grown in the interspaces it is called mixed cropping. The important crops tried were cacao (*Theobroma cacao*), cinnamon (*Cinnamom zeylanicum*), nutmeg (*Myristica fragrans*) and clove (*Eugenia caryophyllata*). Black pepper (*Piper nigrum*) was also grown and trained on coconut trunk. The preliminary results were encouraging.

Concept of multi-storeyed cropping

As a step towards raising the cropping efficiency, combinations of mixed and inter-crops are also being studied. Owing to the differences in the morphological stature, these crops develop their canopies at different strata in the field, simulating the features of a multi-storeyed crop building. A crop combination of coconut + black pepper + cacao/cinnamon + pineapple is illustrated in fig 2. Coconut grown at a height of 10–30m forms the top floor of this crop building. Black pepper, which is trailed on coconut trunks up to 6–8m with little lateral spread, forms the second floor. Cacao/cinnamon with a canopy height of 1.5–2.5m and pineapple/tuber crops having a relatively lesser stature (about 1m) constitute the first and ground floor, respectively. While in a building the ground floor determines the shape and size of the superstructures, in the crop building the top-floor crop determines the agronomic desirability of the nature and type of crops that could be combined.

Agronomic desirabilities

A higher efficiency in the utilisation of the solar energy incident on a given area is obtained as it is intercepted at vertical intervals by the canopies of these crops. Rooting patterns of these crops are also mutually exclusive horizontally, as illustrated in fig 4. Roots of cacao and cinnamon, by virtue of their tapering root systems with relatively lesser lateral spread, do not offer any effective competition with roots of coconut palm (fig 5). Pineapple is a surface feeder, its roots being restricted to a depth of about 30cm only. Thus a higher efficiency in the utilisation of the soil resources and inputs is effected.

Another important agronomic aspect in favour of this intensive cropping system is the efficiency of water use. The potential evapotranspiration of an area is dependent mainly on the evaporative demand of the climate. Therefore, the quantity of water required to permit potential growth and yield of any one crop or a number of crops growing in a given area would remain almost the same, irrespective of the number of crops grown. Irrigation during the rainless period from December to May increased the yield of coconuts substantially (50–100%). The microclimate developed inside this crop building had not only benefited the coconut but also the other crops. Both cacao (variety *forestero*) and black pepper (variety *Panniyur-1*) flowered during the first year of planting².

The growth of weeds in the interspaces

in coconut gardens is a menace. If weeds are perceived as plants with definite requirements of resources such as land, solar energy and management inputs, the question then becomes: 'Why can't the weeds be substituted by some economically useful plants?' In multi-storeyed and other intensive systems of cropping these resources are tapped to the maximum possible extent, with the result that weeds are smothered and the problems caused by weed growth reduced. Further, intercultivation in coconut gardens, which is an expensive operation, could be minimised.

Economic considerations

The advantages of multi-storeyed cropping are manifold with respect to economic aspects also. Apart from increasing the production per unit area and time, the net return per unit amount of money invested is higher. A farmer specialising in a single commodity has to run the risk of market glut due to over-production and the resulting low prices for the produce. Such situations would be disastrous in the case of perennial crops, as has recently happened in the case of arecanut in South Kanara district, India. Diversification of farm produce through multi-storeyed cropping ensures a partial guarantee against this risk. Moreover, under conditions of monoculture, the farmer and his family are under-employed. On the other hand, the employment potential generated by the labour-intensive crop diversifications helps to keep the farmer and his family better occupied.

Prospects and problems

The technology of growing a variety of annual and perennial crops in coconut plantations by itself is not entirely new. At present it is done in a haphazard manner, which results in the mutual competition for light, water and nutrients and the ultimate low productivity. None the less multi-storeyed or any other intensified cropping system is not a panacea for the evils of present-day coconut farming, nor is it without problems. For its success none of the inputs such as fertilizers, seeds, water, agrochemicals, etc. should be in limited supply. The management as well as post-harvest technology for each of these crops has to be perfectly understood and adopted by the farmers. The farmer should be ever alert and vigilant to safeguard his crops from biological hazards and management pitfalls. Yet the strategy looks feasible and to be commended for further consideration.

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