

The coconut growing regions of the world are characterised by warm and humid climate, plentiful sunlight and little variation in the daily and seasonal temperature. Incidentally, these regions are also characterised by high density population and consequent pressure on land. In these areas, therefore, it is imperative to increase the productivity of land by resorting to intensive cropping programmes. While the concept of sequential or multiple cropping in field crops gained emphasis and popularity during the second half of the century, the possibility of increasing agricultural production from perennial crop stands like coconut plantations received attention from research workers only from the late sixties. Growing compatible combinations of perennial/annual crops of other species is the strategy to be adopted for the latter where the land remains committed to the main crop for decades.

Growing perennial crops in the interspace of the main crop like coconut is referred to as mixed-cropping. When annuals are raised, it is designated as inter-cropping. Growing a variety of

CROP MIXING IN COCONUT HOLDINGS

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crops in the interspace of coconut is a widely popular practice in Kerala. This is mainly because of the fact that the agroclimate and other pre-requisites for plant growth such as water, solar radiation, temperature, and soil properties are all available round the year in most parts of the State. But the type of crop mixture chosen is influenced partly by economic reasons like yield and marketability and non-economic reasons such as personal taste, tradition and religious conviction. In short, a close study of the mixed cropped land would reveal an array of low yielding crop plants, grown haphazardly under suboptimal management practice.

Coconut is a perennial palm of the tropics and India has over 11 lakh ha under the crop. It is essentially a small holder's crop

and 98% of the holdings, estimated at 5 million, are less than 2 ha in extent. The average size of coconut holding is only 0.22 ha. The present net income from a hectare of sole crop coconut is about Rs. 6000 annually. With the speedy fragmentation of holdings, growing of more than one crop in the same area is the only possible way of increasing productivity and returns (3) from such small holdings.

A new dimension in crop production namely 'air-space' was identified and successfully put to practice since the early seventies for enhancing agricultural production from coconut stands. (6)

LIGHT PROFILE

The coconut, because of its large canopy, has to be planted

wide apart to permit sufficient sunlight to fall on the leaves. The recommended spacing is 7.5 m. x 7.5 m. accommodating 175 palms per ha. The venation structure of the leaves of coconut permits sunlight to filter down. The light penetration pattern in coconut plantation undergoes changes with the age of the palm. As the trunk height increases, more and more slant sunlight also reaches the ground. When the palms are aged around 20 years about 30 per cent of the incident sunlight reaches the ground. It increases to over 50 per cent when the palms are 50 years old.

ROOTING HABIT

Studies on the rooting habit of coconut revealed that in a well maintained plantation the effective root zone of the palm is confined to a radial distance of 2 m round the base, leaving more than 75 per cent of the land area not fully utilised by the coconut roots. (2) The top 30 cm layer of soil is practically devoid of functional roots and over 86% of the roots are found between 30 and 120 cm depth from surface. The above feature of coconut enables the growing of other crops profitably in between coconut palms without causing root competition among the crops and resulting in more efficient utilisation of the soil resources from the entire area.

INTER AND MIXED CROPPING

It has been established that inter or mixed cropping in coconut plantations has no adverse effect on the productivity of the palms and the soil, provided the crops are selected according to their nutritional and environmental requirements and adequate mana-

gement practices for each crop are adopted. A number of remunerative intercrops have been identified. (8, 10) These include tubers like elephant-foot yam, cassava, sweet potato, ginger, turmeric, chinese potato, lesser yam (*Dioscorea esculenta*) and colocasia, cereals like paddy and ragi and pulses like green gram, black gram, horse gram and cowpea. Similarly, cacao, cinnamon, black pepper, mulberry and coffee (robusta and *Sana Ramon*) have been identified as successful mixed crops.

MULTISTOREYED CROPPING

Several combinations of annual and perennial crops were tried to spot out the best compatible combinations with coconut, as the base crop. (9) The most productive and remunerative combination under the West Coast conditions has been found to be coconut, pepper (trained on the coconut trunk), cacao and pineapple. An area 2m

radius round the base of the coconut palm is left free. Between rows of coconut, 350 - 600 cacao can be planted in one hectare adopting single or double hedge system of planting and a spacing of 2.7 m. Rooted cuttings of pepper (175 numbers) can be planted 1 m away from coconut base on the northern side and the vines trailed on the ground upto the palm and then wound round the base of the trunk. In the alleys between coconut palms and cacao rows, 3500 pineapple suckers can be planted. These crops develop their canopies at varying heights, simulating the features of a multistoreyed building. Coconut with its canopy at 10-30 m from ground forms the top floor, while black pepper trained on coconut trunk up to 5-6 m height forms the second floor. Cacao with a canopy height of 2-4 m and pineapple having a low stature of 1 m constitute the first and ground floor crops, respectively.



Mixed cropping in coconut garden



Multistoreyed cropping pattern

RESOURCES UTILISATION

This combination of crops provides a high efficiency in the utilisation of solar energy incident on a given area, as the sunlight is intercepted at different vertical heights by the canopies of these crops. Their patterns of root development are also different and their root systems do not compete with each other for soil moisture and nutrition. Cacao has a tapering root system and the lateral roots spread only about 60 cm

from the base. Pineapple is a surface feeder. Hence the root systems of these crops utilise the soil resources and inputs more efficiently foraging the entire soil mass.

The water use efficiency is considerably enhanced. The quantity of water required to permit potential growth and production of one crop or a number of crops simultaneously grown on the same area is almost the same, irrespective of the number of crops grown.

AGRONOMIC DESIRABILITIES

The crop combination shows many beneficial effects⁽⁴⁾. The coconut palms are benefited by the favourable ecoclimate developed within the crop mix and yield increases of 60-150 per cent are obtained. Cacao grown in the interspace begins to flower even in the first year and satisfactory yields are obtained during the second year. The gross economic produce harvested annually from one hectare multistoreyed cropping exceeds 36 tonnes.

EMPLOYMENT GENERATION AND RETURNS

The labour requirement of a sole crop coconut plantation of one hectare is 157 man days in a year⁽⁸⁾. The above cropping system requires 366-400 man-days' labour per year and the work is also evenly distributed round the year. Thus multistoreyed cropping more than doubles the employment potential. The labour requirement and the annual expenses and returns of a multistoreyed cropping system are given in Table 1.

Table - 1

Labour requirement, expenses and returns of multistoreyed cropping in coconut plantation (1 ha).

Crops in the combination	Labour requirements (man days)	Annual expenses Rs.	Produce (weight or number)	Value of produce * Rs.	Net returns Rs.
Coconut	157	6,045	17500 nuts	35,000	28,955
Pepper	16	370	88 kg	1,056	686
Cacao	163	3,300	500 kg	7,500	4,200
Pineapple	30	650	3710 kg	2,970	2,320
Total	366	10,365		36,426	36,161

* Coconut Rs. 200/- per 100 nuts; Pepper Rs. 12/- per kg; Cacao Rs. 15/- per kg; Pineapple Rs. 0.80 per kg.

ECOCLIMATE

Multistoreyed cropping creates a more favourable environment for crop production within this cropping system. (1,11) Most important is the development of a microclimatic condition which is highly congenial for dry matter production and accumulation. The maximum air temperature range is lowered by 2 to 3°C and minimum air temperature raised to a similar extent. Thus, the temperature becomes more equitable. The evaporation from the environment inside the system, viz. 2.2 mm, is only one-third of that occurring in agri-met observatory (6.1 mm) during the hot and dry period December to May. The diurnal variation in relative humidity and vapour pressure in the microclimate of the crop mix is 10% compared to 20% in the sole crop coconut stand. Soil temperature is also lowered 3-6°C in summer within the system. It was 26.5 to 29.2°C in multis-

toreyed system while in sole crop coconut stand it ranged from 30.46 to 34.5°C. The diurnal and seasonal variation of soil temperature is also narrowed as compared to a diurnal fluctuation (3-6°C) in the open.

SOIL FERTILITY

Contrary to expectation, the soil fertility in a multistoreyed plantation is steadily improved and built up over the years. This is achieved in several ways. The microbial activity in the soil is considerably enhanced. (5) The cropping system enhances the population of beneficial bacteria and fungi in the rhizosphere of coconut, including the nitrogen fixing and phosphate solubilising bacteria. The indole acetic acid producing *Escherichia* sp. and gibberelin producing *Aspergillus* sp. have been found in the rhizosphere of the crop mix. In a study lasting five years, the organic carbon content of the soil went up from 0.2 to

0.9 per cent, obviously because of the nearly 2 tonnes of dry leaves shed by the cacao plants annually. (11)

CONCLUSION

Crop mixing is not a newly developed cropping system. The farmers, particularly in the tropics, grow traditionally an array of crops, both annuals and perennials, in the interspaces of coconut. However, the productivity of the main crop of coconut as well as the inter or mixed crop is usually affected adversely. The main reasons are the incompatibility of the crops grown and the competition arising out of the overlapping of canopies and roots (7) In multistoreyed cropping system the crops in the combination have been selected based on their canopy stature and rooting habits so that mutual competition for light and nutrient is avoided. In practice, the crops in the suggested crop mixes show a synergistic effect. The long term productivity of the soil is maintained and even improved. However, such crop mixes require adequate supply of soil moisture round the year, either through rainfall or irrigation. It also needs an assured and timely supply of inputs, including plant protection chemicals.

Based on the experiences gained thus far, and with a view to enhancing the gross biomass production that can meet the food, fuel and fodder requirements of the agrarian household and also generate monetary returns, high density multispecies cropping systems are being field tested. The large canopied mango, jack and breadfruit, the medium canopied papaya, banana, subabul, lime and



clove and the small canopied like tropical tubers in middle 18 crop species. The growth and
 pineapple and coffee-San Ramon aged coconut stands. The plant po- performance of the crops during
 are planted along with annuals pulation exceeds 3600/ha involving the first year were satisfactory.

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