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RECENT ADVANCES IN THE MANAGEMENT OF COCONUT-BASED ECOSYSTEMS IN INDIA

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ABSTRACT

Coconut palm (Cocos nucifera L.), cultivated in about 1.1 million hectares, mainly in the southern parts of the west coast of India, is the mainstay of the economy of Kerala State and forms the major visible component of the ecosystem of the area. Traditionally, it is cultivated in small homestead gardens of areas less than 1 ha. and scientific innovations have made little impact on its management by the small farmer. Experimental results have shown that cultivation operations for weed control and proper management of inputs such as nutrients and water can increase the yields of palms substantially. A major scientific initiative in recent years, aimed at increasing the productivity of the coconut areas, is the intensification of land use through combination of compatible crops (and sometimes animals) under or between the palms. Considerable progress has been achieved in identifying the crops that grow well with coconuts and perfecting the agrotechniques of such combination cultures, and the farmers are taking up the practice in a big way. Ecological implications of these new initiatives in the management of the coconut-based ecosystem are examined.

INTRODUCTION

During the past few decades, the average yields of almost all cultivated crops (both in the advanced temperate and tropical regions) have increased. An outstanding example is the recently domesticated para rubber tree (Hevea brasiliensis), the yield of which has increased 17-fold in a century. However, the yield of the coconut palm (Cocos nucifera L.) which has been in cultivation and the economic value of which has been realized since very early times, has remained almost stagnant for many decades. This stagnation is neither because of the lack of realisation of the possibility for higher yields, nor because a high yield level (yield plateau) has already been attained. The palm, which is known as the "Tree of the Heaven" (Kalpa Vriksha) because of its qualities, has also acquired, derogatory names such as "The Lazy Man's Crop" because it lends itself to small-scale production and withstands very "low-level equilibrium" farming conditions.

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DISTRIBUTION OF THE ECOSYSTEM

Coconuts are grown over an estimated 6.5 million hectares in the tropics, mostly in areas of low altitude near the coasts within 20°N and 20°S of the Equator. The world production for 1976 is 40,000 million nuts. The important coconut growing countries are the Philippines, India, Indonesia, Sri Lanka, the South Sea Islands and Malaysia. India, with a total production of 5837 million nuts from 1.07 million hectares, ranks second in the world production and area. The four southern States of Kerala, Karnataka, Tamil Nadu, and Andhra Pradesh account for about 90% of the total area under the crop, with the west coast belt having 87% of the area. Kerala state (Kera is coconut in Malayam, the language of Kerala), alone accounts for about 70% in both the area and production of coconuts in India.

Coconut is essentially a crop of the small farmers in India. Over 90% of the coconut holdings are less than one hectare the average size of a coconut holding in the country is only 0.22 ha. wi hardly 2% of the holdings having areas of two or more hectares. As a sult, the palms constitute an essential component of the garden lands centered around the farmers' dwellings, and its cultivation is the basis of the rural economy where it is grown extensively. It is estimated that about 70% of the rural population of Kerala, depend, at least partly, on coconut for their livelihood. Coconuts are found in the entire west coast belt of India, extending from the southern tip up to about 700 km north. The coconut palm thus, occupies a very prominent position in the agriculturally managed ecoystem (agro-ecosystem). In other words, the ecosystem along the west coast of India is essentially a coconut-based ecosystem.

ECOPHYSIOLOGICAL CONDITIONS OF THE COCONUT GROWING AREAS

The climate of the west coast of India is characterized by a mean monthly air temperature of 20° and 30°C, high relative humidity and heavy, but unevenly distributed, monsoon rains. In this coconut belt on the west coast of India, rainfall increases from the south to the north. The total rainfall at Kayangulam in South Kerala is 2500 cm per year with only 2-3 dry months, whereas at Kasaragod in North Kerala, the total rainfall is about 3500 mm but the dry period extends to about 5 months (mid-November to mid-May) (Fig.1). The effect of climatic factors on the palm characters and production of nuts has been studied. Although changes in the weather preceding the harvest is important the critical period is the first 3-4 months of development of the nuts after fertilization of the flowers.

Even though the relative ease of adaptation of the coconut palm has enabled it to spread widely over the very varied pedological domains of the tropical zone, the best coconut soils are characterized by an open texture (such as deep alluvium and sandy loam), well drained with adequate supply of soil moisture and nutrients, and at least 1 m depth without any

hard layers. But coconuts are grown under diverse soil conditions ranging from littoral sands to clayey soils, ill-drained low lying areas to well-drained hill slopes, strongly acidic peaty soils to alkaline calcereous soil. The major coconut soils types of Kerala are laterites, red sandy loam, coastal sandy soils, reclaimed marshy soils and alluvial soils. In general, these soils are shallow to moderately deep with low water table, poor in fertility, excessively leached and acidic (Khan et al., 1978).

TRADITIONAL METHODS OF MANAGING THE COCONUT ECOSYSTEM

One of the remarkable features of the coconut palm is that it is adaptable to varied levels of management. Even under relatively poor conditions of soil fertility and crop management, the palm yields without much effort on the part of the farmer. The seasonality of production, the sustained nature of income from the crop throughout the year, and the possibility of storing or marketing the nuts without processing make coconut a low-risk crop. In contrast is the seasonal and often fluctuating production and perishable nature of produce from arable farming. Even though the beneficial effects of management inputs such as fertilizers, irrigation, etc. are realized on research farms (see below), fertilizers are seldom applied. But, organic manures and other farm and household wastes are usually thrown around the coconut palms. As a result, a continuous system of nutrient cycling can be said to be operating in these coconut-based ecosystems centered around the homestead.

In the homestead gardens, coconuts are seldom grown in pure stands; the palms are generally grown mixed with other annual or perennial crops. Thus, many short duration (annual) crops and perennials such as jack fruit (Artocarpus heterophylla Lam.) areacanut (Areca catechu L.), bread fruit (Artocarpus altilis Fosb.) mango (Mangifera indica L.) and cashew (Anacardium occidentale L.) are found with coconuts. However, in most cases, such mixed cropping is done in a haphazard manner without giving adequate attention to the ecophysiological requirements (water, light, nutrients, etc.) of the additional crops and of coconuts, so that such practices often lead to the reduction in the yields of both coconuts and the other crops.

The labour for the crop can be spread fairly evenly over the year, and almost all the cultural operations (except harvesting) are much easier than arable farming. The majority of the small holdings make use of family labour. Therefore, these small holdings receive more managerial attention compared to the large holdings.

ADVANCES IN THE ECOSYSTEM MANAGEMENT

The few advances in the management of coconut palms, in the recent years due to scientific initiatives, can be broadly grouped into (a) input

management and (b) intensification of land use through crop combinations.

(a) Input management

Based on the field studies conducted to evaluate the effects of various inputs and to find the optimum time, amount, method and source for obtaining best yields. To illustrate the effect of fertilizers and other management aspects on the growth of coconuts a long term observational plot has been maintained at the Central Plantation Crops Research Institute (CPCRI), Kasaragod, since 1916. There are three plots: one receives fertilizers and cultivation practices regularly, the second one receives only cultivation operations but no manures or fertilizers, and the third one is under total neglect. The average yields of the palms during the past 60 years (average for 10 year intervals), are presented in Fig. 2. Since the palms were getting old (they are now about 80 years old), underplanting was done in 1967 with seedlings obtained from nuts of selected West Coast Tall mother palms. The young palms also received the various management practices as in the original treatments. In 1972, the plots were subdivided into two to accomodate more treatments. These young palms show remarkable variations in their growth habits; those receiving the recommended practices including fertilizers start bearing nuts in about 6 years from planting, whereas those under neglected conditions are yet to emerge from their planting pits. The contrasting characters of these young palms, photographed in September 1978, 11 years after planting, are shown in Fig. 3.

The effects of inputs such as nutrients (N, P, and K) and water on the growth and productivity of the palms have been amply illustrated in a series of statistically laid out field experiments at CPCRI and other locations, where graded quantities of one or more inputs are given. The results of the response of young palms to nutrients and water are summarized in Nelliat et al,.(1978) and Nelliat and Padmaja (1978).

The experimental results (obtained so far at the CPCRI) of the effect of the three major inputs, cultivation operations, nutrients, and water increasing the yields of coconuts are presented in Fig. 4. The Figure also gives the additional yields obtainable through superior genotypes and crop combination techniques. In a perennial, cross-pollinated crop like coconut, the time required to replace a sizeable percentage of existing palms with superior genotypes is long and therefore the impact of superior genotypes in augmenting production is likely to be felt only after a long time. Figure 4 shows that even with the existing varieties, the average yields of palms can be easily doubled with proper agronomic management.

(b) Intensification of land use

The growth habits and growing conditions of the coconut palm facilitate the growth and production of other crops between or under them.

Therefore, to increase the productivity of an ecosystem where coconut is an important and long-term component, monocropping of coconut is not the best way, no matter how high the yield of the palms. The rationale for crop combinations is that in monocrop stands, soil and solar energy - the two basic resources of crop production - are not being utilised to the fullest extent. On the other hand, in compatible crop combinations, the crop canopies intercept and utilize solar energy from different strata and, their root systems are localized in distinct zones (Nair, 1979).

Various systems of crop combinations such as intercropping (the additional crop is of short duration), mixed cropping (with long duration crops), multistoreyed cropping (mixture of short and long duration crops forming multilevel canopies), and mixed farming (a unit consisting of fodder crops and animals under coconuts) have been evolved (Fig 5). Considerable information on the agronomic, economic, and biological advantages of the different land use patterns have been accumulated (Nair, 1979). Intensive cropping is of particular importance in the areas affected by the dreaded malady of "root wilt " disease of coconut as the productivity of such areas can be increased by crop combinations, apart from the possible ameliorative effects of crop combinations in reducing the disease intensity.

Normally, the yields of crops in such crop combination methods are likely to be less than the yields of monocrops of the individual species; but results of mixed cropping of coconut per palm actually increased in the crop combination as compared to that of the same palms in their previous stand of monocrop. The results from an eight year-old mixed cropping experiment are given in Table 1. The crop combination also causes a favourable modification of the ecoclimate within the plantation. The most striking aspect of the modification is the reduction of the daily evaporation within the crop stand during the dry months as observed by Nair and Balakrishnan (1977). Microbiological investigations also indicate that the crop combinations favour the activities of favourable micro-organisms (Nair and Rao, 1977; Potty, 1977). These results indicate that the interaction of the individual components of the crop combinations brings about biological complements in the use of inputs.
Other aspects of plant community interactions in crop combinations with coconuts have been discussed in detail (Nair, 1978).

CONCLUSIONS

The way in which the environment is exploited and the ecosystem is manipulated to increase productivity is of particular importance in a perennial crop like coconut, which is also of economic importance to the farmers and the province. Land use decisions in such cases require a co-ordinated assessment of the potential socio-economic and ecological repercussions (Ovington, 1974). Evidently the ideal management system for the small holder farming of coconut should not be capital- and energy-intensive. The practice has to be based on the principle of "ecodevelopment".

where the ecosystem is manipulated with an ecological awareness to obtain sustained production offering maximum employment possibilities and a reasonable and acceptable way of life to the un- and under-employed rural folk and with minimum strain on the non-renewable resources of the world. In this context, the intensification of land use in coconut areas based on scientific multiple cropping is of considerable importance. It can easily be rated as the most important scientific initiative in the management of the agroecosystems involving the small holdings of coconut farmers in India.

Ryszkowski (1974) has described the cultivated field ecosystems as artificially maintained simple ecosystems with little possibilities of modifying the effect of climatic factors, and with an open cycle of mineral circulation. Forests, on the other hand, is complicated; have high water storage, and well developed mineral retention and they do modify climatic factors. The crop combination system, with coconuts as the pivotal component, is an artificial ecosystem with a semi-closed cycling of mineral nutrients (Nair & Khanna, 1978) and some possibilities of influencing the weather (Nair and Balakrishnan, 1977). Thus, they occupy an intermediate position between cultivated fields and man-made forests, as such are not expected to pose ecological hazards to the extent posed by intensively managed agricultural systems. They also conform very well to the concept of agroforestry (King and Chandler, 1978).

The research input in developing these agro-systems (coconuts) and solving the many problems concerning them has been very meagre. The limited data obtained has shown that intensive management of the coconut ecosystems is a promising method in improving the income of small farmers. The development of appropriate technology for increasing efficiency of farming is not an easy task and the improvement from the present state of near-neglected management of coconut lands to high-intensity crop combinations is a big step.

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COMMENTS

Manguiat, I.J.: How would you explain the difference in the microbial populations between an agro-system with coconut alone and that with coconut and cacao.

Nair, P.K.R.: The possible reasons are that in multiple cropping situations, the higher content of organic matter results in more substrate for microbial activity and provides favourable microclimate for microbial proliferation. Root exudation from cacao and for coconut , also favour microbial activity.

Ong, T.S.: What is the distance between individual coconut plants in your system of (a) intercropping tapioca with coconut and (b) intercropping tumeric with coconut?

Nair, P.K.R. In both the systems, the intercrops are grown according to the normal practices for the monocrops stands of the species in

between the existing stands of coconuts (175 pa/ms/ha). Tapioca is planted at 1.0 m x 1.0 m spacing and tumeric in raised beds of four rows per bed and 30 cm between and within rows.

Table 1. Yield of coconut in the coconut + cacao mixed cropping experiment at CPCRI (Cacao was planted in 1970 when coconuts were 20 years old)

Cropping system	No. of plants/ha		Yield of coconuts per palm						
	Coconut	Cacao	Pre-experimental period (average for 2 years)	Experimental period					Increase over pre-experimental period
				74-75	72-74	76-77	75-76	Average 5 years	
Coconut alone	175	-	68	149	120	88	115	118	50
Coconut + cacao as single hedge between coconuts	175	350	57	164	112	83	117	119	62
Coconut & cacao as double hedge between coconuts	175	600	39	142	109	68	84	101	62

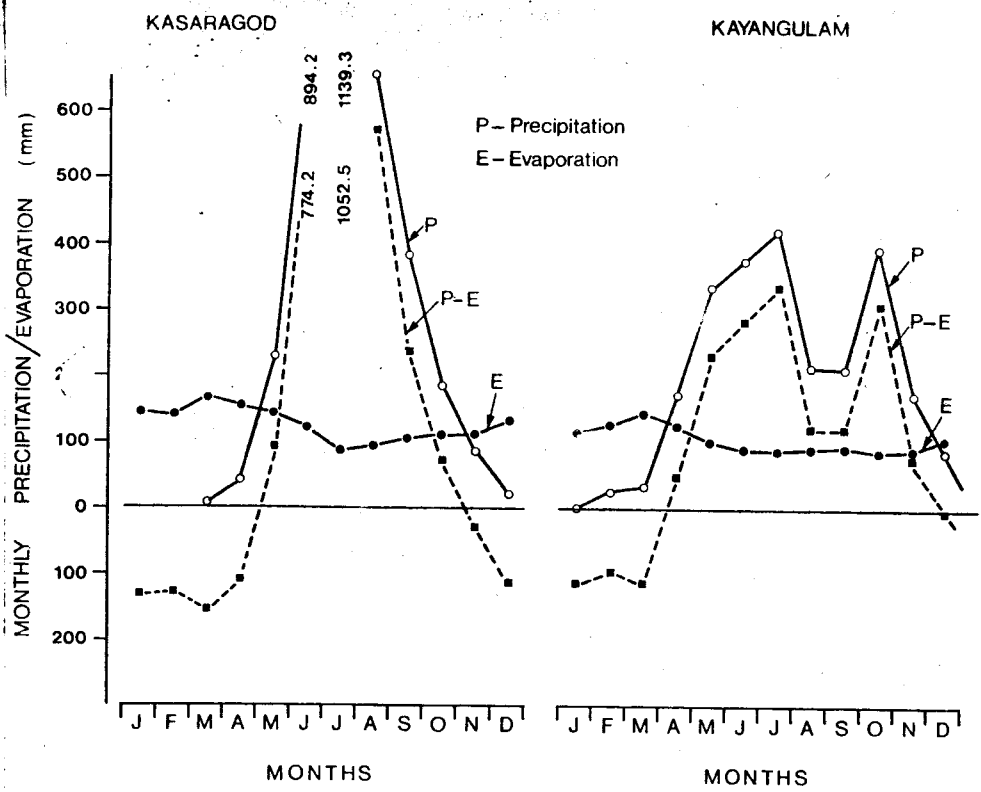

FIG. 1 : WATER SURPLUSES AND DEFICITS DURING THE YEAR AT KAYANGULAM, SOUTH KERELA AND KASARAGOD, NORTH KERALA, BASED ON 20 YEARS DATA.

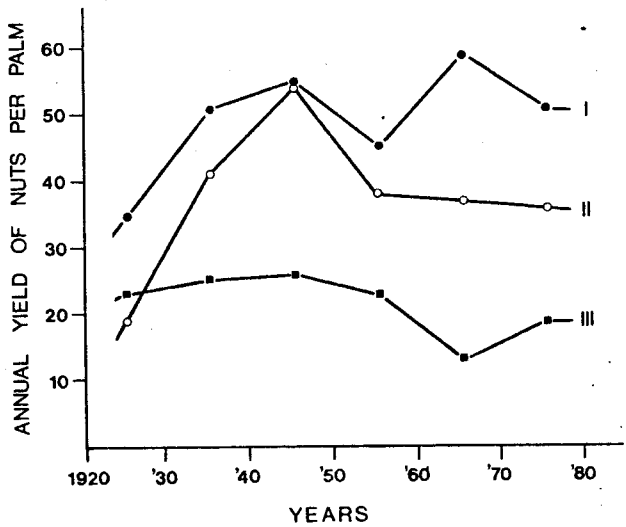

FIG. 2 : YIELD OF COCONUT PALMS IN PERMANENT OBSERVATIONAL PLOTS AT KASARAGOD DURING THE PAST SIX DECADES, AVERAGED OVER 10 YEARS INTERVAL.

I FERTILIZER AND CULTIVATION
II CULTIVATION WITHOUT FERTILIZER
III WITHOUT CULTIVATION AND FERTILIZER.

A B C

Fig. 3: Photographs of the young coconut palms in the permanent observational plots at Kasaragod.

A: cultivation without fertilizer
B: fertilizer without cultivation
C: fertilizer and cultivation

•(All palms are progenies of the same mother palm, planted in 1967 and photographed in 1978).

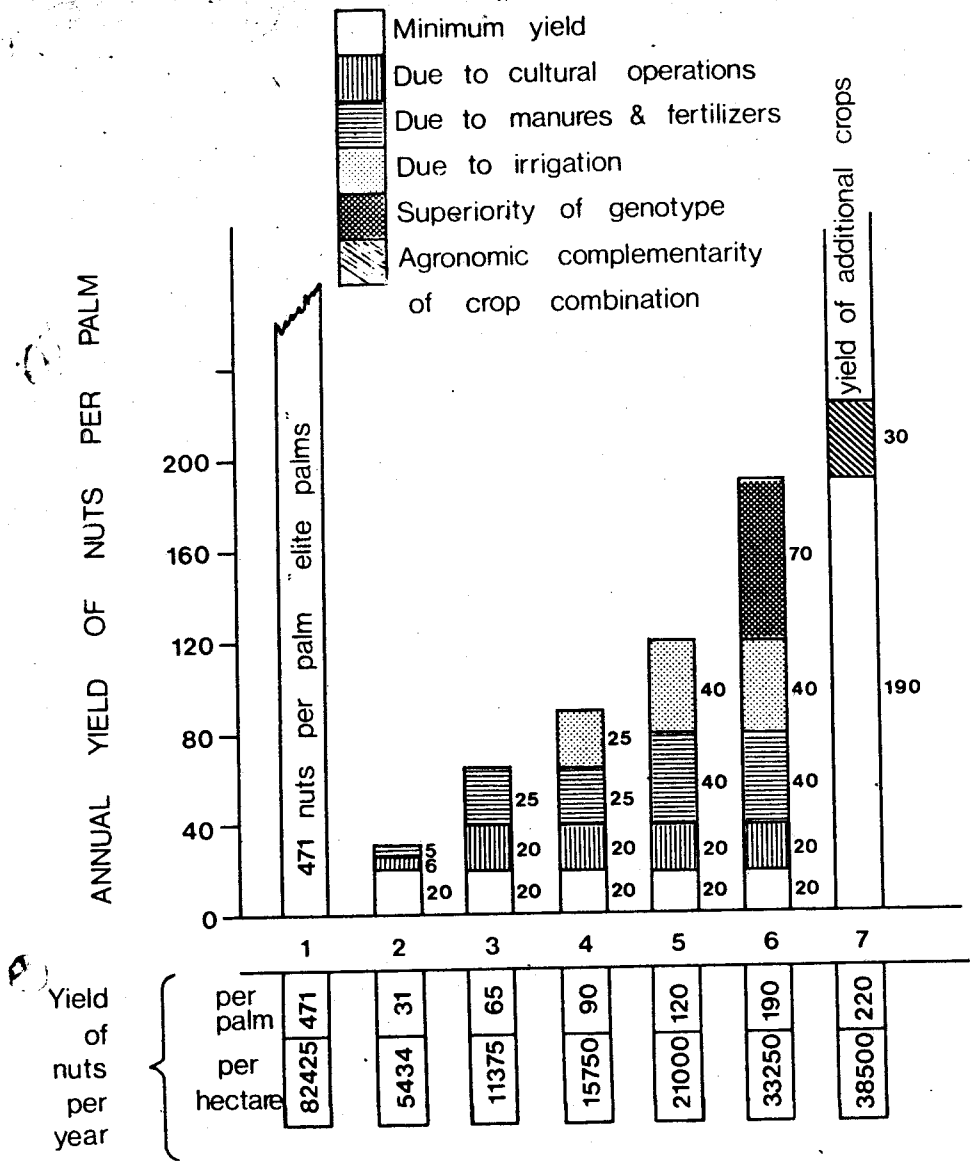

Fig. 4: Effects of various inputs on the yield of coconuts and the targetted productivity of the ecosystem.

1. Best results obtained,'elite' palms
2. National average
3. Rainfed management (average)
4. Irrigated management (average)
5. Good management, WC Tall variety
6. Good management, high yielding genotypes
7. Good crop combination system

Fig. 5A-5D : Some examples of intensive land use systems in coconut areas.
A : Intercropping with tumeric (Curcuma longa L.)
B : Intercropping with greater yam (Dioscorea alata L.)
C : Multistoreyed crop combination of coconut + black pepper (Piper nigrum L.) + cacao + pineapple (Ananas comosus Merr.)
D : Family farm unit of 1 ha. with coconut + black pepper + fodder grass + animals, looked after by the farmer and his family.