

# Crop Management in Cocoa



केन्द्रीय रोपण फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद)

कासरगोड - ६७१ १२४, केरल, भारत



**CENTRAL PLANTATION CROPS RESEARCH INSTITUTE**

(Indian Council of Agricultural Research)

**KASARAGOD - 671 124, KERALA, INDIA**

# **CROP MANAGEMENT IN COCOA**

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***Published by***

Dr. V. Rajagopal  
Director  
Central Plantation Crops Research Institute  
Kasaragod - 671 124  
Kerala, India.

***Photo***

Front cover : A good yielding cocoa plant

Back cover :



1. Coconut and cocoa mixed crop
2. Arecanut and cocoa mixed crop
3. Cocoa nursery

***Cover design***

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K. Syama Prasad

August, 2001

ATIC Series Publication No. 2

# Prepared by Dr. S. Arulraj, Head of Division (Social Sciences)

- under the Scheme for "Establishing Agricultural Technology Information Centre" (ATIC),  
National Agricultural Technology Project (NATP)

# 'CROP MANAGEMENT IN COCOA

## Introduction

Cocoa (*Theobroma cacao* L.) belongs to the family Sterculiaceae. It is a native of the Amazon region of South Africa. It is a beverage crop and it is known to be used even before tea and coffee. The main cocoa producing countries are Ghana, Nigeria, Ivory Coast, Brazil, Cameroon and Malaysia. The cultivation of cocoa on a commercial scale started in India in early 1970s. It is grown as a mixed crop in coconut and arecanut plantations. To a limited extent, it is also grown as an understorey crop in cleared forests. Cocoa has the important potential of serving economic, social and environmental ends.

## Climate and soil

Cocoa is grown between 20°N and 20°S latitude, but maximum number of cocoa gardens is situated between 10°N and 10°S latitude. Cocoa can be grown upto 300 m above mean sea level. The plant needs equitable

climate with well-distributed rainfall. It requires an annual rainfall of 1500-2000 mm with a minimum of 90-100 mm rainfall per month. If dry periods are prolonged, irrigation to the crop is necessary. Temperature range of 15°-39°C with an optimum of 25°C is considered ideal.

Cocoa requires deep and well-drained soils. Poorly drained soil affects the growth of plants. Majority of area under cocoa cultivation is on clay loam and sandy loam soil. It grows well in the pH range of 6.5 to 7.0.

## Shade

Cocoa has evolved as an understorey crop in the Amazon forests. Thus commercial cultivation of cocoa can be taken up ideally in plantations where 50% of light is available. In India, coconut and arecanut gardens are suited best for cultivating cocoa. Under arecanut, 30-50% of sunlight penetrates through the canopy, which can be intercepted by cocoa (Fig.1).

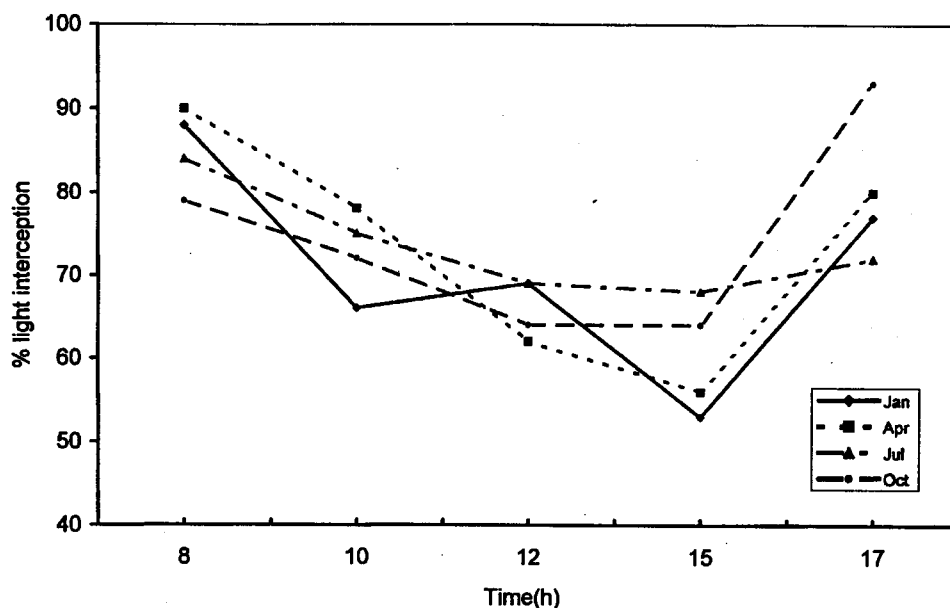


Fig.1. Light interception in an arecanut garden

## Varieties

There are three main types of cocoa viz., Criollo, Forestero and Trinitario. The Criollos are characterized by soft pod husk with 20-30 white, Ivory or pale purple beans. The beans ferment faster with weak chocolate flavour. They are less vigorous and susceptible to diseases. The Forestero belongs to large group of cultivated semi-wild types. They are hardier than Criollos and most of the cultivated area at present comprises Forestero. Forestero has hard green pods with 25-45 beans. The Trinitario type has characters intermediate to Criollo and Forestero. Trinitario plants are believed to be cross populations of these two types of cocoa.

Over the years, several varieties of cocoa have been developed in different countries. The ICS clones were developed in Trinidad. The Brazilian varieties include IMC, NA, PA and SCA series. Studies carried out at CPCRI Regional Station at Vittal have led to the identification of the following high yielding accessions: NA33 x ICS89, I-14 x NC42/94, I-14 x II-67, I-56 x II-67, I-56 x III-105, Amel x NA33, II-67 x NC42/94, II-67 x NC29/66 and NC45/53.

## Planting material

Planting material is an important input in any cropping system. It should give high yield of good quality beans under normal growing conditions, viz. i) Vigorous growth, ii) Early bearing, iii) High yields, iv) Good value of bean weight (1.07 g/bean or 93 beans/100 g), shell (10-12%) and fat content (not less than 55%), v) High value of pod index, vi) Degree of resistance/tolerance to local pests

and diseases, vii) Adaptation to withstand environmental stress conditions such as severe drought, flooding etc.

**Seed propagation:** Cocoa can be planted either as seedling or through vegetatively propagated material.

Cocoa beans from ripe pods within fifteen days of becoming ripe can be used for raising seedlings. But less mature pods will give poor seedling growth and possibly leaf abnormalities. Normally germination will be at least 90% and will be complete in 15 days. Removing the mucilage by rubbing the fresh beans in sawdust or sand and washing them can speed it up. This will hasten it by 7 days. This will also take care of ants and other insects that get attracted to the mucilage.

**Selection of seed:** As cocoa seeds lose their viability soon after they are taken out of pods, fresh beans shall be used for sowing.

Cocoa seed is epigeal in its growth, i.e., the cotyledons are raised above the soil surface by growth of the root. It is therefore necessary to ensure that the seed is not planted too deep lest it may fail to emerge. Seed should be planted not more than 1 cm below the surface with the hilum downwards but it is safer to lay them flat rather than to plant on end. This will avoid any possibility of planting the seed with hilum upwards, in which case the seedlings may become distorted as they develop. The nursery will require watering, which is commonly done every two or three days although daily watering is sometimes recommended especially during summer months. A nursery

of 1000 seedlings may need 90-115 litres of water at each watering which implies a considerable labour requirement for a large nursery if water supply is not piped. Hence it is wise to go for automatic unit that can keep the whole nursery area humid through mist mechanism. In case it proves to be costly, one can think of using gravitational force in attaining the mist through the permanently laid pipes from an elevated overhead water tank. This will take care of both labour problem as well as the possible injuries to the grafts while watering manually.

The seedlings will be ready for transplantation to main field after about 3-4 months.

### Grafting

This has been the commonly practised method in this region due to easy operation. It is similar to the practice followed in other perennials like cashew. Quite a good success rate is achieved through this method. Majority of the scion sticks will be constituted by fan branches as the number of chupons obtainable from each plant is very few.

Plants (root stocks) of 2-3 months old are shaved off their top portion and given a vertical cut at the top with the grafting knife to a length of 2-3 cm down. The scion stick with leaves removed but pre-cured buds at top is given slanting cuts at the bottom so as to give a 'V' shape of around 2 cm length. The scion stick will be around 12-14 cm long and will be secured in the stock cut held tight together with the help of a polythene tape of 1.5 cm wide.

In cocoa, epicotyl grafting can also be effectively followed as in the case of cashew and mango. However, the temperature and humidity maintainable systems are a must. More attention is being paid to tissue culture in cocoa propagation these days to save time and space.

### Economics of cocoa graft production

Economics of production of 10,000 grafts taking 70 % of grafting success for 6 months period:

Gross income @ Rs. 10 per graft	Rs. 70,000/-
Total expenditure	Rs. 27,270/-
Net income	Rs. 42,730/-

The profit margin of Rs. 42,730/- from a period of 6 months with a generation of 280 mandays employment proves the technology to be highly viable on economic front.

### Nursery management

Cocoa nursery requires adequate shade, irrigation and wind protection. The land should be level. A simple structure (pandal) with locally available poles would be sufficient. Coconut and arecanut fronds can be used for providing shade. Alternately, shade trees like areca, oil palm, *Glyricidia*, silver oak or *Erythrina* can also be used for shade. It is ideal to have 50% shade in the nursery. Nursery can also be prepared by erecting cement/granite pillars and covered by agroshade nets with 50% shading. Irrigation is given through micro sprinklers.

The pot mixture consisting of topsoil, sand and FYM in the ratio of 2:1:1 is to be prepared for ensuring good growth of seedlings or grafts.

Recommended insecticides and fungicides will take care of common pests and diseases in the nursery. Weeds are not a problem in nurseries and can be controlled by manual weeding.

Fertilizer application in nursery is not common unless the soil used as medium is less fertile and the growth of seedlings is poor. Application of urea or compound fertilizer at the rates of 0.5-2.0 g or 1.0-3.0 g respectively, the rates increasing from a minimum at 2 months to a maximum at 6 months. Foliar application of urea at 1.5 % concentration is also adopted.

### **Time of planting**

Cocoa can be planted either in the beginning of South West monsoon (May-June) or end of monsoon (September).

### **Spacing and planting**

Cocoa is planted either under forest trees or other crops. It can be established under forest trees by thinning the forest to the desirable shade levels. Under forest trees, spacing of 2.5 x 2.5 m to 3.0 x 3.0 m is found suitable. Cocoa seedlings are planted in pits of 50 cm<sup>3</sup> filled with compost. In areca garden, cocoa is planted in 2.7 x 5.4 m spacing, where main crop is planted at 2.7 x 2.7 m. When grown

as mixed crop with coconut, two systems of planting are usually followed viz., single hedge of 2.7 m apart or double hedge of 2.5 m apart.

### **Manuring**

An annual application of 100g N, 40g P<sub>2</sub>O<sub>5</sub> and 140g K<sub>2</sub>O per tree in two equal split doses is given during May and September. During the first year of planting, 1/3 dose is recommended, while in second year 2/3 dose is given. Fertilizers are applied uniformly around the base of tree upto a radius of 75 cm and forked for incorporation into the soil.

### **Irrigation**

Cocoa is usually grown in areas where water availability is adequate. But in some areas although plenty of rainfall is received, long periods of dry spell ranging from 3 to 6 months are common. Since cocoa plants are sensitive to drought, irrigation in such cases is essential. During summer, as it exists in Southern India, the crop is irrigated at weekly intervals. When it is grown as mixed crop with arecanut, the crop is to be irrigated once in a week during November-December, once in 6 days during January-March and once in 4-5 days during April-May with 175 litres of water. Cocoa responds well to drip irrigation. Maximum yields are obtained in cocoa, irrigated through drip irrigation with 20 litres/day/tree (Fig.2).

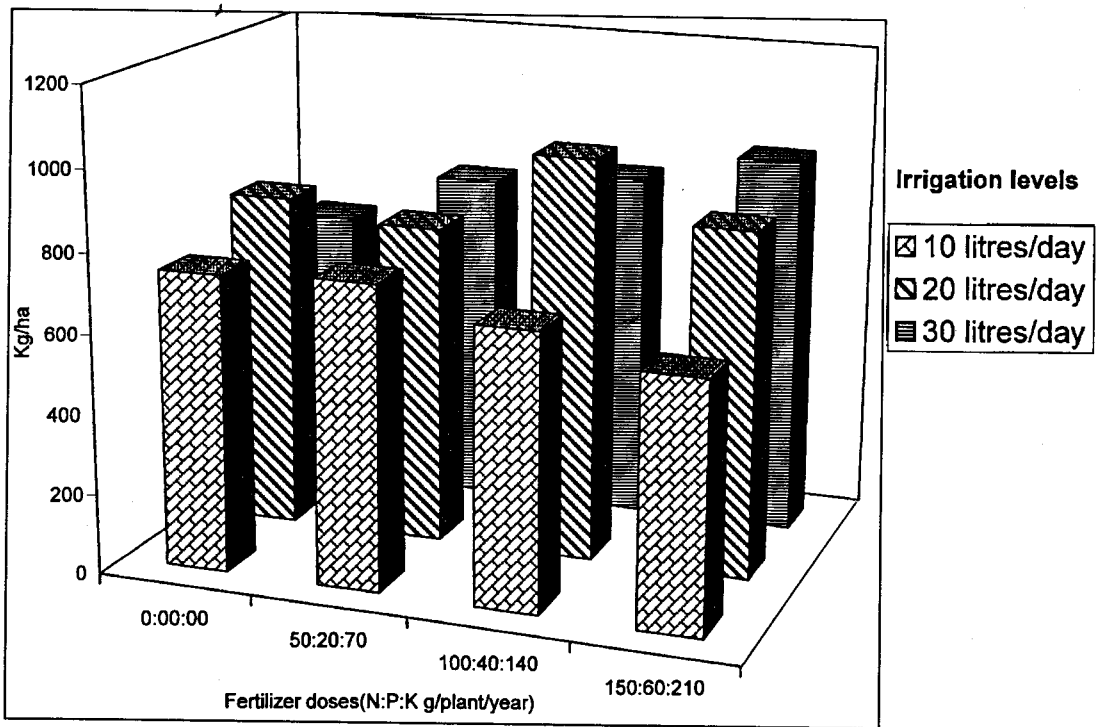


Fig.2. Bean yield in relation to irrigation

### Pruning

In cocoa, the nitrogen supply to the tree will determine the amount of vegetative growth, while photosynthesis will determine the carbohydrate reserves. The ratio between the nitrogen supply to the tree and the carbohydrate reserve within the tree will determine the quantity of fruit, which reaches maturity. Only the branches on the outside part of the canopy of the tree will produce photosynthates and thus make a real contribution to the carbohydrate reserves of the tree. All branches without leaves, but within the canopy could therefore be considered parasites because they consume more nutrients than they produce. The maximum photosynthetic activity will occur when the

maximum surface area of cocoa leaf per unit ground area is exposed to light.

The cocoa tree requires to be pruned regularly to maintain good canopy. In young cocoa, it is necessary to have formation pruning. This is done mainly to adjust height of first jorquette. The jorquette is allowed to form at a height of 1-2 m that will help in easy cultural operations. Pruning in mature cocoa includes two types viz., sanitary pruning and structural pruning. In sanitary pruning, diseased or unnecessary branches are removed. Structural pruning is done to shape the canopy to desired size and architecture. Maximum leaf area should be maintained with pruning practices to avoid self-shading of leaves. Cocoa grows in a

series of storeys. The chupon or vertical growth of plant terminates at the jorquette where 4-5 fan branches develop. Further chupon develops just below the jorquette and continues vertical growth till another jorquette is formed. When grown as mixed crop in coconut or arecanut gardens, it is desirable to restrict the height of canopy to single storey level. In studies on spacing and pruning, a spacing of 2.7 x 5.4 m and a canopy area of 15-20 m<sup>2</sup> were found to give the highest bean yield (Fig.3).

### Biomass production

In one hectare of areca garden, 650 cocoa plants produce about 11 tonnes of biomass. This includes prunings, leaf fall and pod husks. This biomass is available for

recycling. It can supply approximately 161 kg nitrogen, 12.5 kg phosphorus and 201 kg potash per hectare. In addition to this, it also results in increasing the microbial activity in soil. The number of beneficial organisms like fungi, bacteria and actinomycetes available in the micro-environment are also increased which are beneficial to crop growth.

### Mulching and weed control

Mulching helps in conserving moisture in the soil. Any organic matter available like banana waste, areca residues, coconut husk and cocoa pod husk can be used for mulching. In cocoa plantations, annual and perennial weeds are found to affect the growth of young plants. Young cocoa

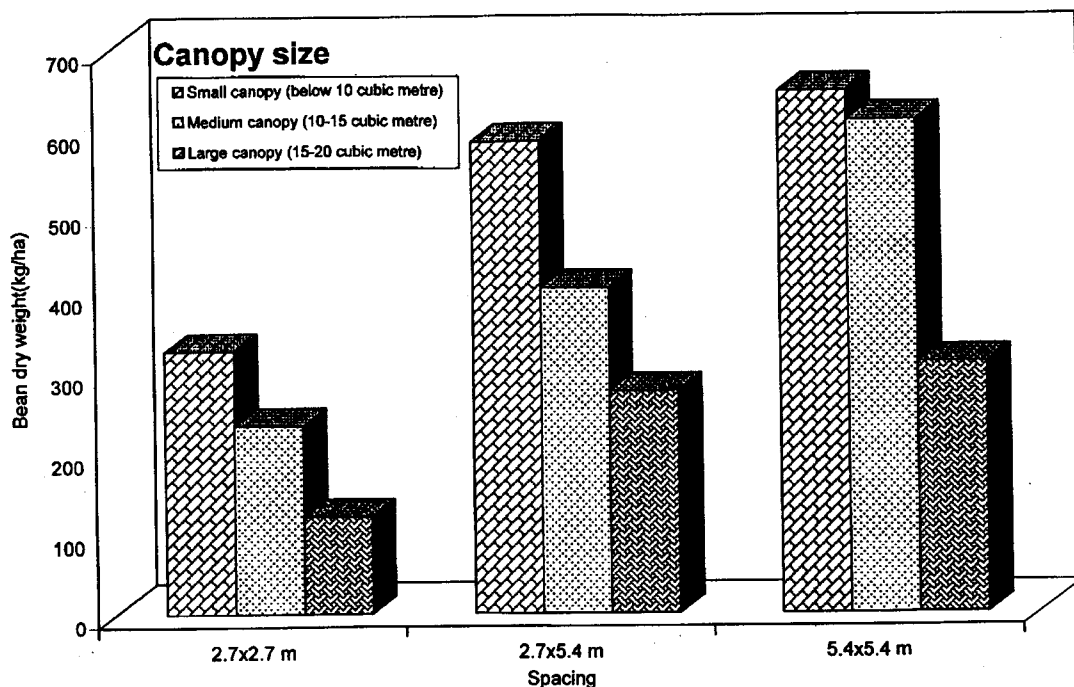


Fig.3. Bean yield in relation to pruning

plantations are usually weeded manually. Though the use of herbicides is widely practised in other countries, no weedicide is recommended in India.

### **Harvest**

Flowering in cocoa starts from second year after planting. The pod development takes about 140-160 days. Each pod has 25-45 beans embedded in white mucilage. Generally, there are two main harvest seasons viz., September-January and April-June.

Ripe pods are harvested without damaging the flower cushions. The pods are cut with the help of a sharp knife. Harvesting is done at an interval of 10-15 days. The damaged, unripe and infected pods are separated for ensuring good quality beans after fermentation. The harvested pods are kept for about two days before breaking open for processing. After breaking pods crosswise, the placenta is removed along with husk and beans are collected for fermentation.

### **Post harvest technology**

**Fermentation:** Fermentation of cocoa beans is essential to remove the adhering mucilaginous pulp, to develop flavour and aroma precursors, reduce bitterness, kill the germ of the seed and to loosen the testa. Different methods of fermentation are (1) box (2) heap (3) tray and (4) basket methods. However, box and basket methods are recommended depending on the quantity of beans to be fermented.

**Box method:** This method is more applicable to large estates or central fermentaries. Boxes of 60 cm x 60 cm x 45 cm made of wood and having reapers at the bottom to allow the sweating from the pulp to drain out and to provide aeration are used. The boxes could be arranged in tiers for transferring beans from one to the next in line below. Two detachable wooden planks are provided on one side of the box for transferring (mixing) the beans by removing the planks.

The beans are loaded in fermentation box and covered with banana leaves or gunny. The mixing of beans is effected while transferring to the next box after 24 hours. The mixing is done to facilitate uniform fermentation and to maintain proper temperature, moisture and aeration during fermentation. The temperature of the fermentation mass will rise to 42-48°C after about 48 hours of fermentation. Again transferring of beans is done at 72 hours of fermentation and the final transferring is done after another day's fermentation. A total of six days (144 hours) are required to complete the fermentation.

**Basket method:** Bamboo or cane basket of suitable size could be used for fermenting small quantity of beans. One or two layers of banana leaves are placed at the bottom with provision to drain the sweating. The basket is filled with the beans and the surface is covered with banana leaves. A small weight is placed over the banana leaves. The basket is placed

over a raised surface to facilitate drainage of the sweating for one day. Later the basket is covered with thick gunny bags. The beans are mixed thoroughly on the third and fifth days and again covered with gunny. The fermentation will be completed at the end of the sixth day and the beans are withdrawn for drying.

### **Drying**

After fermentation, the beans can be dried by sun-drying or artificial drying. The fermented cocoa beans have considerable moisture (55-60%) and the drying rate is dependent upon temperature and the airflow.

**Sun drying:** Sun drying should be adopted as far as possible, as it gives superior quality produce when compared to that by artificial drying. The fermented beans are spread in thin layer over a bamboo mat or cement floor and dried for 5-6 days. The beans are to be stirred from time to time for uniform drying. The moisture content of well-dried beans is around 6 to 7%.

**Artificial drying:** During the monsoon period, artificial drying is to be adopted. Electric oven or conventional Samoan type dryer could be used. The duration of artificial drying varies from 48-96 hours. The drying of beans at high temperature should be avoided as it results in low quality end product. Slow drying in the initial stage gives better quality beans. Mould growth is to be prevented during drying as it affects the appearance of the beans.

**Electric oven:** The beans are to be dried for 8-10 hours at 50-55°C for the first two days, followed by continuous drying at 60°C. The total drying period will be 72-96 hours. The beans are to be stirred at regular intervals for uniform drying and to prevent clump formation.

**Samoan type dryer:** The temperature should be maintained around 60-70°C for the first 48 hours and then temperature can be raised to 80°C to reduce the bean moisture to 6%. The end-point of drying can be determined by rubbing the beans with hand after cooling when it should produce a crackling noise.

### **Grading and storage**

The dried beans after cooling to room temperature should be cleaned before storage. The flat, slaty, shriveled and broken beans and other extraneous materials are removed. The cleaned beans are packed in polythene-lined (150-200 gauge) gunny bags. The bags are kept on a raised platform of wooden planks. The beans should not be stored in rooms where spices, pesticides and fertilizers are stored as the beans may absorb the odour from these materials.

### **Final processing**

There are two types of techniques used in the final processing of cocoa - the expelling method and the roasting method. The press system, as the latter is called, is the modern method and has been adopted

by all large scale processing plants. The expeller system considered as less economical still prevails in some parts of the world.

### **Press system**

The fermented and dried cocoa beans are first inspected for moisture content and then classified by colour. The beans are cleaned by removing all extraneous materials. They are passed into roasters which reduce the moisture content, lower the acidity and deepen the colour. Then the beans are passed to huskers to remove the shells and the nibs are separated. The shells are disposed of as fertilizers, mulch or fuel. In these processes, the beans lose weight by about 20 %. The roasted and husked nibs are fed into heated disc crushers for grinding. The cell walls of the nibs are broken and a substance variously named as liquor or paste or mass, which contains about 55% fatty matter, comes out. The cocoa liquor is subsequently passed through a cooling tunnel and solidified into liquor blocks or kibbled liquor. These processes constitute the first stage of conversion of beans into various products. In modern plants, all these activities are well integrated and mechanized and fully sealed. Once the beans are fed, cocoa liquor comes out packed, ready for distribution. In the second stage, the cocoa liquor is pressed to extract cocoa butter. The butter is then cooled and disposed of either in the form of liquid or slabs. Another product

obtained is cocoa cake during the pressing of the liquor. The cake is pulverized and passed through breakers and grinders. To remove acidity and deepen the colour, it is treated with alkaline substances. This also increases the solubility of the powder.

### **Expeller system**

In the expeller system, the beans are cleaned and fed into the crushers. Natural butter is pressed out. The cake residue containing the shell is sent for solvent extraction. Residual butter can be extracted from these defatted cakes and the residues are used as cattle feeds.

### **Yield**

In India, cocoa cultivation is confined to Kerala, Karnataka and Kanyakumari district of Tamil Nadu. The crop is mostly grown in the interspaces of coconut and arecanut gardens as a mixed crop. When cocoa is grown under arecanut with a spacing of 2.7m x 5.4m, one hectare area accommodates about 680 trees. Under normal cultivation practices, each cocoa tree yields about 2 kg dry beans annually.

### **Economics**

Cocoa is mainly grown as a mixed crop in arecanut and coconut gardens in Kerala and Karnataka States. The flow of costs and returns exhibit the same pattern of coconut and arecanut as furnished in the following table.

**Economics of cocoa cultivation as a mixed crop in arecanut garden under optimum management conditions in Kerala (Rs/ha).**

Years	Total cost	Total returns	Gross margin
1	19200	-	-19200
2	6700	-	-6700
3	4900	-	-4900
4	12000	12000	Break even
5	12000	16000	4000
6 onwards	12000	24000	12000

The domestic demand for cocoa is far ahead than that of domestic supply and hence cocoa and cocoa-based products are imported from Latin America and other countries. To

improve the production and productivity of cocoa in India, necessary developmental support is needed for the production and marketing of cocoa and cocoa based products.

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