



Nursery Manual on Cocoa



**ICAR - CENTRAL PLANTATION CROPS
RESEARCH INSTITUTE (CPCRI)**

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Technical Bulletin :
Nursery Manual on Cocoa
CPCRI Technical Bulletin No.: 109
Centenary Publication No.: 44

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December 2016

Printed at
Hanuman Printers, Vittal.
E-mail : hanumanprintersvtl@gmail.com

NURSERY MANUAL ON COCOA

Introduction

Cocoa (*Theobroma cacao* L.) is an important plantation crop and a compatible mixed crop in palm based cropping systems of India. Commercial cultivation of cocoa started four decades back mainly in the agro-climatic region, Western ghats hills and plains. Currently cocoa is being cultivated in 78 thousand hectares covering Kerala, Karnataka, Tamil Nadu and Andhra Pradesh states with 16 thousand tonnes production. The demand for cocoa in Indian chocolate industry is portrayed as 60,000 MT for the year 2025. About 2,20,000 ha of area to be brought under cocoa to meet out this demand for which 150.7 million seedlings are required. Area expansion programs taken up by National Horticulture Mission of Ministry of Agriculture needed quality planting materials to increase the productivity from 380 kg to 500 kg per hectare. It necessitated improved varieties, mother trees, establishment of seed gardens/ clonal orchards, scion banks and scientific production strategies for effective nursery management. Cocoa can be multiplied both by seeds and vegetative means, which offers wide scope for multiplication of planting materials in multitudes. Growth, health and standard of the seedlings in the nursery will decide the performance of this perennial crop in the plantation. This manual detailed the basic and advanced nursery techniques to be followed for cocoa planting material production.

Improved varieties

The Central Plantation Crops Research Institute (CPCRI) at its Regional Station at Vittal, Karnataka initiated systematic cocoa research, evaluated germplasm collections, conducted selection breeding and hybridization programs and developed seven high yielding varieties. These varieties exhibited adaptability in multiple environments and crop shades, showed vigour, optimal canopy, earliness in bearing, high yielding potential, quality beans and tolerance to major pests, diseases and low moisture stress. These varieties are being supplied as seed pods, seedlings and grafted plants to farmers and developmental agencies.

Varieties of Cocoa

Hybrids

VTLCH-1 Hybrid, vigorous, early, heavy bearer Green to Yellow pods No. of beans/ pod- 42 Single dry bean weight- 1.00 g Dry bean yield/ tree/ year- 1.48 kg	
VTLCH-2 Hybrid, early, heavy bearer with medium canopy, tolerant to black pod rot Green to Yellow pods No. of beans/ pod- 40 Single dry bean weight- 1.15 g Dry bean yield/ tree/ year- 1.15 kg	
VTLCH-3 Hybrid, heavy bearer, suitable for water limited conditions Green to Yellow pods No. of beans/ pod- 45 Single dry bean weight- 1.07 g Dry bean yield/ tree/ year- 1.45 kg	
VTLCH-4 Hybrid, heavy bearer, suitable for water limited conditions Red to Orange pods No. of beans/ pod- 43 Single dry bean weight- 1.01 g Dry bean yield/ tree/ year- 1.25 kg	
VTLCH-5 Hybrid, heavy bearer, suitable for high density planting both under arecanut and coconut Green to Yellow pods No. of beans/pod- 43 Single dry bean weight- 1.10 g Dry bean yield/tree/year- 2.5 to 3 kg	

Clones

VTLC-1

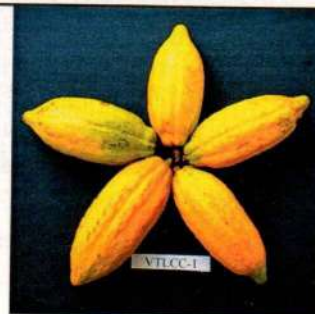
Clonal selection, heavy bearer, both self and cross compatible

Green to Yellow pods

No. of beans/ pod- 37

Single dry bean weight- 1.05 g

Dry bean yield/ tree/ year- 1.33 kg



VTLC-2

Selection, stable high yielder both under arecanut and coconut, withstands biotic and abiotic stress

Red to Orange pods

No. of beans/ pod- 42

Single dry bean weight- 1.13 g

Dry bean yield/ tree/ year- 2.5 kg



VTLC-3

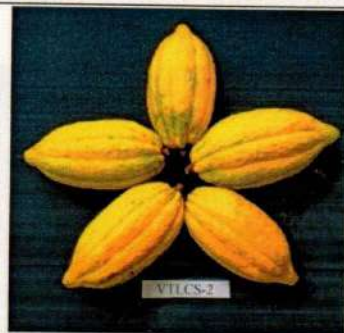
Selection, stable high yielder both under arecanut and coconut, bold and bigger beans, less incidence of pests and diseases

Green to Yellow pods

No. of beans/ pod- 42

Single dry bean weight- 1.21 g

Dry bean yield/ tree/ year- 2.7 kg



All varieties are suitable for the agro-climatic region Western Ghats Hills and Plains covering Kerala, Karnataka, Tamil Nadu, Goa and Maharashtra under arecanut and coconut shades. Clones and selections are suitable for North Eastern zones and coconut gardens of Andhra Pradesh as well.

SEED PROPAGATION

Selection of mother trees and seed pods

Seed is the cheapest and easy propagule of cocoa, which is available in plenty. Each fruit or pod of cocoa will have around 35 to 50 seeds/ beans depend upon the type and size of pods. To identify suitable mother trees from larger populations of cocoa especially from native cultivars and local land races, certain selection criteria are being followed. Progressive farmers can follow these factors for their own selection and seed production of promising types.

Mother trees	: Forastero and Trinitario type of cocoa with green or red pods.
Bearing behaviour	: 80-100 pods/tree/year after twelve years of age.
Pod type	: Smooth surfaced with shallow furrows without prominent constriction at the neck.
Pod size	: Medium to large pods of not less than 350 g weight.
Pod value	: No. of pods required to produce 1 kg beans to be not >12.
Husk thickness	: 1 cm
No. of beans	: >35/ pod (bold beans from middle of pod)
Bean weight	: Wet : 3 g, Dry : 1 g and above



Forastero mother tree

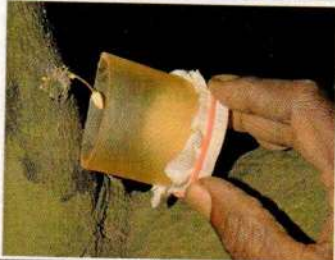
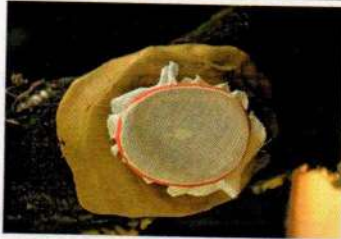


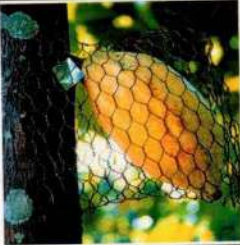
Trinitario mother tree

Method of hand pollination

Hybrids of bi- parental crosses are being produced with artificial pollination. Hand pollination is practiced to confirm the compatibility reaction of genotypes and in crossing of distant genotypes with specific objectives for developing hybrid varieties.

Steps in hybridization

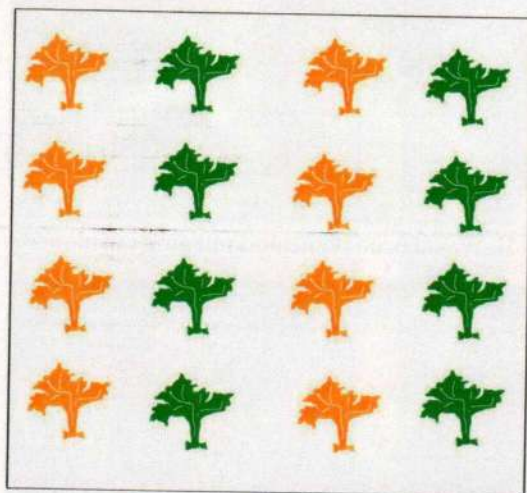
Selection of flower bud which is about to open the next day recognized by its whitish colour and swollen appearance.	
Covering the bud with hood of plastic tube/hose pipe piece of 5 cm x 1.5-2 cm size, closed with muslin cloth at the top, tied with a rubber band. This ensures circulation of air and exclusion of insects.	
Sealing of the tube to the bark with plasticine/ glaze putty fully enclosing the bud.	
Collection of freshly opened flowers from the desired male parent. Stamens are carefully taken out by pushing the corresponding petals or ligules.	
Deposition of one entire anther with a part of the filament on the stigma. If the staminodes surrounding style are long they may be removed to ensure easy access to style.	

Labelling the pollinated flowers with tin foil pieces fixed in the cushion using ball pins.	
Removal of hoods after 24 hrs of pollination. Fertilization will be confirmed in three to five days by the visual swelling of the ovary.	
Covering the developing pods with wire mesh after six to eight weeks to protect them from mammalian pests.	

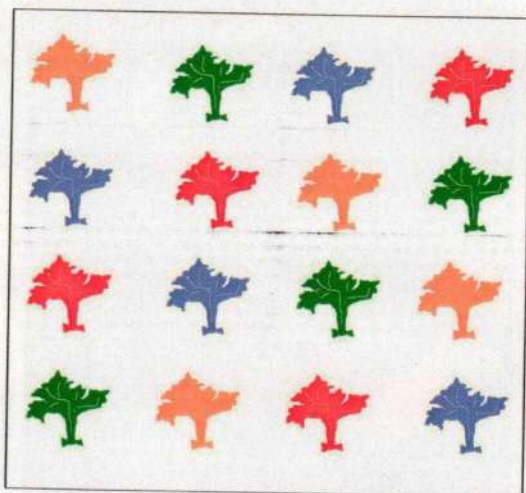
- For artificial pollination emasculation is not necessary due to the presence of self-incompatibility in cocoa. For selfing, hand pollination is done using stamens from the same flower.
- In order to prevent undue shedding and wilting of fruits from hand pollinations, it is usual to remove all the developing fruits on the tree produced by open pollination.
- A full grown tree will produce around 10,000 flowers in a year, of which 50 to 100 will develop as mature fruits in the normal condition.
- When flowers are plentiful, one person can do 300 pollinations per day to get 150 successful hybrid pods.
- If unpollinated, the flower abscises within 24 hours. Cocoa also has a physiological flower and fruit thinning mechanism at 25, 50 and 70 days after pollination which is called 'cherelle wilt'.
- Pollination success depends on season and number of flowers opened at the time. Hand pollination is effective in the morning hours between 8 to 10 am.

Seed Gardens or Clonal Orchards

Presence of self incompatibility is observed in many cocoa populations. It is the failure of fruit setting with pollen from the same plant (self-incompatibility) or with pollen from other plants (cross-incompatibility). The incompatibility in cocoa is widely observed as gametophytic, where the pollen tubes develop normally but the male gamete does not fuse with the female gamete. Among the populations self-incompatible but cross-compatible genotypes are available which are widely used for hybrid production. The purpose of seed garden or clonal orchard is to produce seeds of known parentage and proven performance. Based on earlier progeny trials, best combining parents are selected, multiplied as clones and established as seed gardens or clonal orchards. These well designed gardens will produce hybrid pods through natural cross pollination. If the orchards are assembled with two self-incompatible but cross-compatible parents they are called as bi-clonal orchards and if planted with multiple clones called as poly-clonal orchards. It is important to establish such clonal gardens in research institutes and regional nurseries to meet out the future demand of seedlings. Six bi-clonal and one poly-clonal orchard are being maintained in isolation at CPCRI, Research Centre, Kidu, Karnataka. Kerala Agriculture University (KAU) is also maintaining such clonal orchards.



Bi-clonal orchard



Poly-clonal orchard

Seed pod harvest and sorting

- Ten year old mother trees are used for seed pod collection if it is of seedling origin and five years old in case of clonal trees.
- Cocoa pods take 150-170 days to attain harvest stage after pollination. They remain without damage upto a maximum of one month on the tree and harvesting is done at 15 days interval.
- Correct stage of maturity is assessed from visible change of colour of green pods to yellow and red pods to orange. Immature pods will give poorer seedlings with leaf abnormalities.
- Harvesting of seed pods is done with a sharp knife without damaging the flower cushions or the bark as flowering and fruiting in cocoa is cauliflorous i.e. truncate bearing.
- CPCRI developed a cocoa harvester with light weighted telescopic pipe and blades sharpened at both sides.
- Well matured and healthy seed pods are sorted out from the bulk and broken either by hitting against a hard surface or with a wooden hammer. Gentle cut with knife may be practiced with due care without damaging the seeds. Seeds are to be extracted without placenta.
- If pods are harvested at third-fourth maturity they can be kept for four days in the nursery in shade and used for long distance transportation.
- Fumigation of seed godowns/ stores/ sorting sheds with formalin is advised in humid conditions to prevent pod rot infection.



Cocoa harvester



Harvest cocoa without damaging cushions



Sorting of healthy seed pods

Seed standards, viability and seed treatment

- Seeds/ beans in cocoa are recalcitrant without dormancy period and so beans once extracted from pods are to be sown immediately. Over ripe pods tend to have viviparous germination.
- Bold and big beans extracted from middle portion of the pods will give 90-95 percent germination.
- In the ripe pod, seed is surrounded by a mucilaginous pulp which contains a germination inhibitor. Gentle rubbing of seeds with sand or saw dust will speed up the germination. As a prophylactic measure, Bavistin at rate of 2 g for 1 kg seeds may be applied and seed dressing with insecticides is practised in rare occasions with less dosage.
- Germinability of freshly extracted seeds can be extended for four to six weeks by storing in moist charcoal and packed in poly bag, which favours long distance transport and germplasm exchange programs. In few countries, the seeds are mixed with sawdust, testa is removed, peeled seeds are then treated with a fungicide, either by washing in a fungicidal solution or by dusting and packed in polythene bags. It is observed that seed stored by this method preserve its viability without germinating for three to four weeks.
- Fumigation of seed godowns/ stores/ sorting sheds with formalin is advised in humid conditions to prevent pod rot infection.



Extract middle beans



Vivipary in over ripe pod

Polybag Nursery

- To get better root and shoot growth, to make the planting and transportation easy sowing seeds in polythene bags is being followed.
- Black polybags of 6"x 9" size with 250 gauge thickness is used.
- Potting mixture for cocoa is 2:1:1 Soil: Sand: FYM. Organic manures like coir compost, vermicompost, neem cake and bean husk/ shell composts can also be used in place of Farm Yard Manure.
- Soil solarization by sun drying and covering of potting mixture with black polythene sheet during March-April will enhance seedling vigour and health.
- Biopriming of potting mixture with 'Cocoa Probio', *Pseudomonas* microbial cultures will enhance the growth and health of seedlings.
- Cocoa nursery is to be located in a heavily shaded area. Shade net (50-75%) covering either green or black nets with permanent pillars in an area of 2 acres will hold 50,000 bagged seedlings.
- Polybags are to be arranged in neat rows leaving walking path for monitoring and better management.
- Cocoa is sensitive to water stress and so regular watering is required. Misting is good in the initial days of germination followed by hose irrigation.
- Drainage in the nursery is important during monsoon season. Poly bag nursery may be raised in glass house during rainy season.



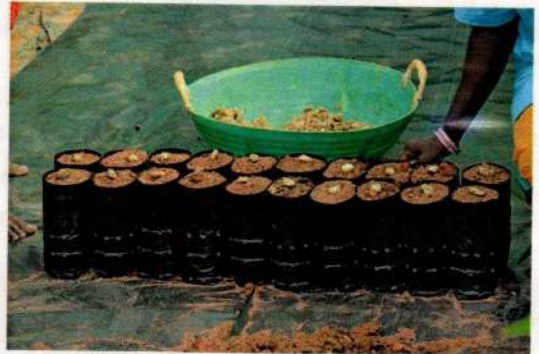
Shade net nursery

Sowing and Germination

- Main harvest season in the traditional zones starts in April- May months and sowing to be completed before onset of monsoon. Continuous showers will affect germination and invite fungal infections.
- Sowing is to be done by keeping seeds horizontally or vertically with hilum end down and just covering with sand. Shallow sowing is preferable.
- Seeds start germination in about a week and will continue for another one week. Epicotyl type germination is observed in cocoa, where cotyledons are taken above ground in the process and is called 'soldier phase'.
- Cocoa seeds will germinate at any time of the year with adequate irrigation.
- May sown seedlings will be readily available for planting during September-October, the post monsoon season in the high rainfall zones like Kerala and Karnataka.
- Compact blocks on varieties raised with grafted plants showed second season of bearing during post monsoon season which is good for nurseries which are in operation throughout the year. It favours planting during June- July with onset of monsoon in low rainfall areas or the non-traditional zones.



Seed treatment with sand



Sowing



Germination- soldier phase



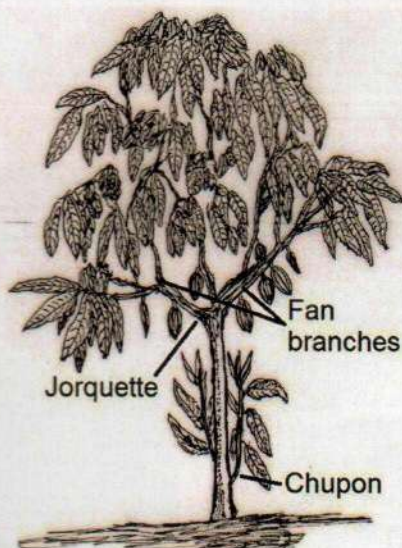
Germination

VEGETATIVE PROPAGATION

Grafting and budding are being followed in multiplication of cocoa. Cocoa is a cross pollinated crop showing wide genetic variability. To maintain true to type of genotypes, to get early yield, to maintain optimal canopy, asexual or vegetative or clonal propagation is followed. It also ensures multiplication of identified high yielding varieties and elite clones. Soft wood grafting method is standardized at CPCRI with 85% success rate. For the grafting technique to be successful stock and scion compatibility is very important, which exists in cocoa.

Root Stock and Scion Selection :

- Three to four months old seedlings raised in polybags are used as root stocks for grafting.
- Scion sticks of 12- 15 cm length with 2- 3 buds are collected from desirable high yielders.
- Root stock stem and scion stick are to be of same thickness and physiological age for successful graft union.
- Scion sticks of chupons (orthotropic shoots) will give seedling like architecture, whereas bud sticks of fan branches (plageotropic shoots) will give bushy appearance. Fan grafted plants needed formation and structural pruning from the second year of planting itself



Plant habit of cocoa

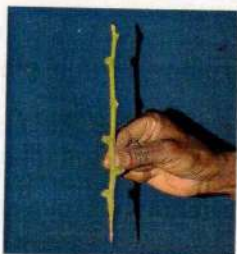
Grafting Technique



Giving a horizontal cut in the upper portion of the root stock with a grafting knife



Making a vertical slit of 2 to 3 cm down (cleft) on the decapitated root stock



Giving a 'V' shaped slanting cut of 2 to 3 cm length (wedge) to the defoliated scion stick



Insertion of the scion into the stock (wedge into the cleft)



Tying tightly with a polythene strip or tape of 1.5 cm width over the joint



Covering with polythene pouch so that the graft joint and scion stick won't dry up and be removed after 15-20 days



Perfect graft joint will occur in one month, polythene strip tied over graft joint will be removed after two months. Successful graft will be ready in 5 months for field planting

- A skilled person can make 300 grafts per day.
- The emerging shoots from the rootstocks are to be removed regularly.
- October to December season is best for grafting and all other seasons are suitable with sufficient irrigation.
- Grafting pest and disease resistant clones on susceptible rootstock is an added advantage of this technique and old, unproductive plants can be rejuvenated through this technique by top working. Conservation of multiple varieties on a single tree is also possible.

Transplanting

- Only vigorous seedlings are to be used for transplanting based on height and stem girth.
- If raised in polythene bags, the poly covers are to be removed while planting and graft joint should be above the soil.
- The planting material may be of 4-6 month old seedling or grafted plant.
- It is advised to plant seedlings and clones of multiple genotypes to overcome the incompatibility problem in cocoa.

Strategies for diseased tracts

- Seed pods free of *Phytophthora*, thrips, mealy bug and tea mosquito bug attacks are only to be harvested. Pods half eaten or damaged by rats and squirrels can be discarded.
- Nursery should not be raised in areas susceptible to vascular streak die back (VSD) disease.
- Poly green house can be utilized for screening, protection and hardening of seedlings.
- Preventive sprays to be taken up during monsoon season.
- Covering the floors with black polythene sheet will assure weed free nursery.



Pod rot



Thrips attack



Squirrel damage

Nursery pests

Seedling dieback/ seedling blight caused by *Phytophthora palmivora* Butl. is very common in the cocoa nurseries of Kerala and Karnataka during rainy season. Younger seedlings are more susceptible to the disease and severe infections observed in grafted and budded plants also. The disease initiates from the collar region, cotyledonary stalk or leaves as dark brown to black discoloration. It spreads to the entire stem causing wilting, defoliation and ultimate death of the seedlings.

Foliar infection caused by *Colletotrichum gloeosporioides* Penz. is also common in almost all nurseries. Infected seedlings look very unhealthy due to leaf blight, crinkling of leaves and stunted growth. White thread blight caused by *Marasmius scandens* Massee leading to dieback of six month old seedlings has been reported as a problem in nurseries with high humidity, poor aeration and low availability of sunlight. Zinc deficiency symptoms are also reported.

Removal and destruction of infected seedlings from the nursery are very important to check the secondary spread of the disease. The disease incidence can be considerably reduced by improving the drainage facilities in the nursery and by providing proper shade. Drenching the seedlings with Bordeaux mixture (1%) or Copper oxychloride (0.2%) just before the onset of monsoon and thereafter at frequent intervals will control seedling dieback.



Seedling dieback



VSD affected nursery (Kerala)

Nursery pests

Mylokerus weevils (*Mylokerus viridanus*) skeletonise the foliage and higher incidence has been noticed during July to September. Leaf eating caterpillars also cause severe damage in nurseries. Spraying the lower surface of the foliage with Fenthion 0.05% is recommended. If the damage is severe in young plants, spraying by mixing 16 ml Dimethoate in 10 litres of water may be taken up.



Leaves eaten by caterpillars

Selection of seed centres

ICAR- CPCRI nurseries are recognized by National Horticulture Board with four star grading. It is recommended to procure planting materials from research institutes, recognized nurseries and regional nurseries. ICAR- CPCRI supplied parental material to seventeen regional nurseries established in five states with funding from Directorate of Cashewnut and Cocoa Development (DCCD), Cochin. These are in operation in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra and Goa for unhindered supply of planting materials in the region. Apart from that, parental clones and hybrids are supplied to AICRP-Palms centres to meet out the location specific demands.

COST OF PRODUCTION OF SEEDLINGS AND GRAFTS

No.	Item	Rate (Rs.)	Quantity	Cost (Rs.)
1	Shade net (75%) (sq.m)	Rs.20/-	2000	40,000
2	Farm Yard Manure (MT)	Rs.1500/-	40	60,000
3	Polythene bags 6x9" size 250 gauge with 9 punches (kg)	Rs.100/-	250	25,000
4	Pepsi covers (15 x 6 cm) (kg)	Rs.60/-	100	6,000
5	Preparation of potting mixture (2:1:1:Soil:Sand:FYM) collection of sand, sieving, mixing, filling, arranging in beds, sowing, resowing if required, 6 weedings (per bag)			
		Rs.2/-	50,000	1,00,000
6	Grafting (collection of scion, rearranging grafted seedlings and left over root-stocks) (per graft)			
		Rs.6/-	50,000	3,00,000
7	Labour charges for watering and maintenance of nursery	Rs.100/- 1man/day	1 year	30,000
	Cost of production of seedling	I year	Total	2,61,000
	Cost of production of graft	I year	Total	5,61,000
	Sale of seedling	Rs.10/ seedling	50,000 nos.	5,00,000
	Sale of graft	Rs.20/graft	50,000 nos.	10,00,000
		Cost: Benefit ratio seedling		1:1.92
		Cost: Benefit ratio graft		1:1.78
		II year onwards (without shadenet cost)		1:2.26 1:1.92

Cocoa Seedling Standards

No.	Characters	Standards
1	Age of the seedling	5- 6 months
2	Height of seedling	45- 50 cm
3	Girth of seedling	3.5- 4 cm
4	No.of leaves	5- 6 pairs
5	Growth	Straight from the middle of the poly bag, without branching or jorquetting.
6	Foliage	Green, healthy, without crinkling and nutrient deficiency, middle leaves of 15 cm length and 6 cm width.
7	Root	Tap root branched with young spreading roots without netting.
8	Potting mixture	2: 1: 1 Soil: Sand: FYM in poly bag of 6" x 9" size and 250 gauge thickness.
9	Precautions	Free from nursery diseases and pests.
Ball of earth in the poly bag should be wet and loose without pot bound condition. Care should be taken not to break or damage the tap root. Seedlings should not be kept in the nursery over ten months.		

Cocoa Graft Standards

No.	Characters	Standards
1	Method	Soft wood/ wedge grafting
2	Type of root stock	Bulk Forastero/ Trinitario seedlings
3	Root stock raising	Poly bag nursery
4	Size of polythene bag	6" x 9" size and 250 gauge thickness
5	Potting mixture	2: 1: 1 Soil: Sand: FYM
6	Age of root stock	4- 5 months

7	Root stock size	Height 50 cm, 3.5 cm girth with 7 pairs of leaves
8	Scion size	Thickness same as root stock, soft woods of 12- 15 cm length with 2- 3 buds, defoliated
9	Graft union	20 cm above soil, about 2 cm thickness, should be covered with polythene pouch to avoid drying
10	Grafted plant	Height 60 cm, 7 pairs of healthy leaves, stem straight without jorquetting
11	Root	Tap root with well spread young roots
12	Precautions	Remove the polythene pouch after 15-20 days

Label for sale of planting material

Name of the crop : Cocoa

Botanical Name : *Theobroma cacao L.*

Variety : VTLCH-1

Source : CPCRI

Propagule: F1 Seedling /Graft

Age of the plant : 5 months old

Height : 60 cm

Girth : 4 cm

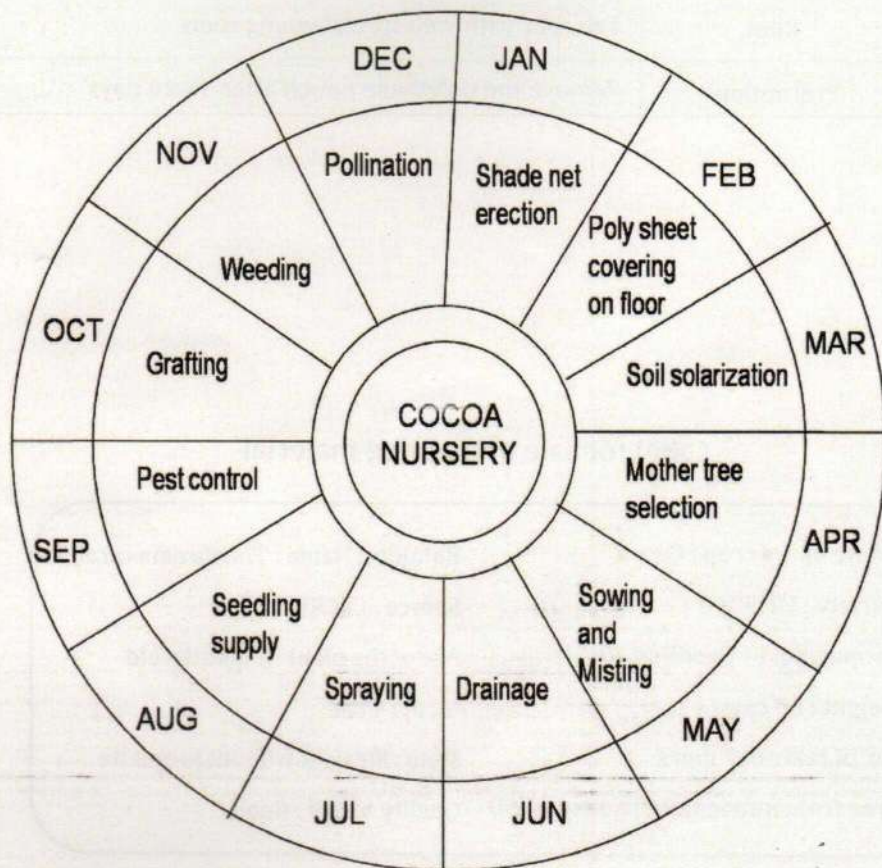
No. of leaves : 7 pairs

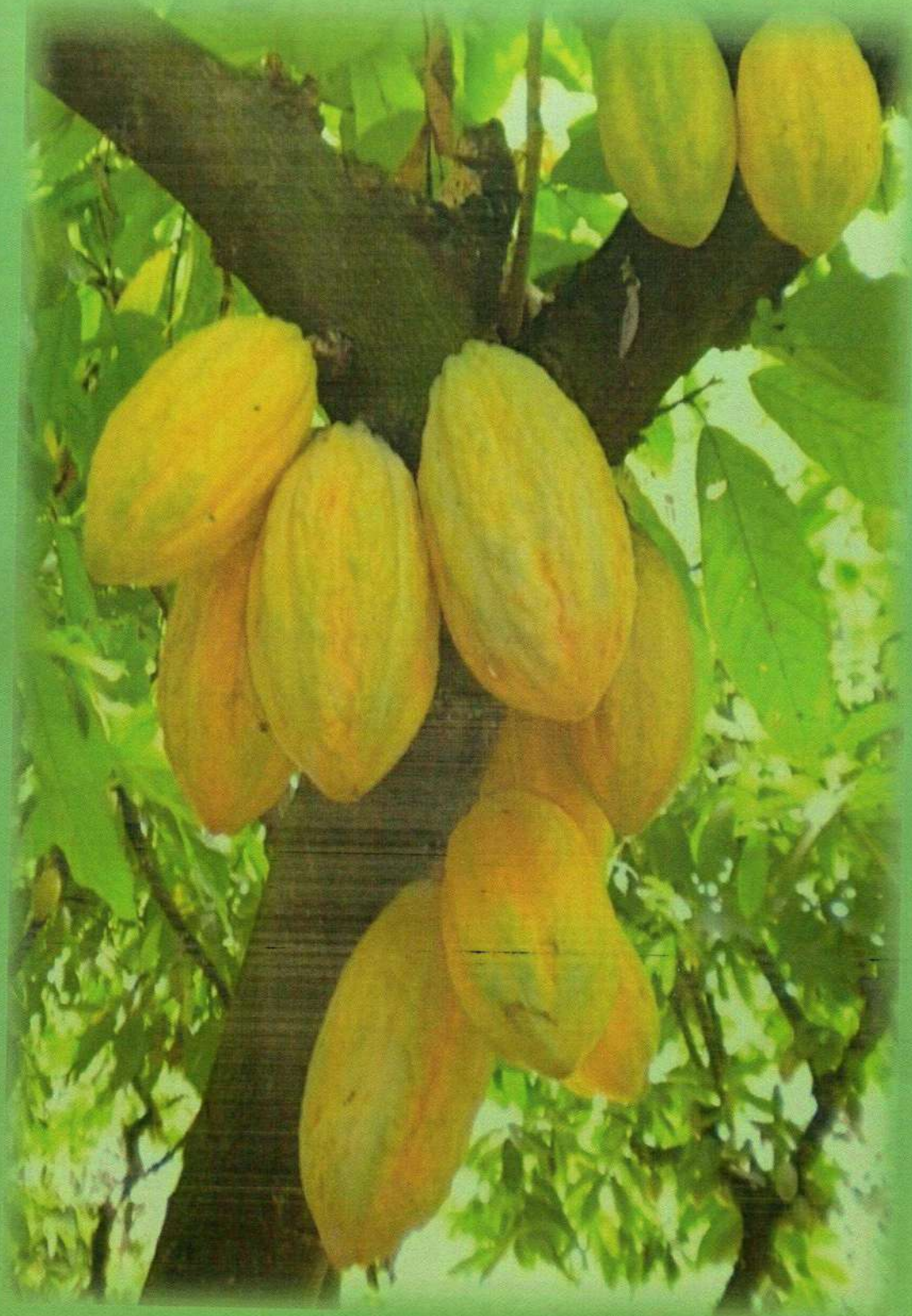
Stem : Straight without jorquette

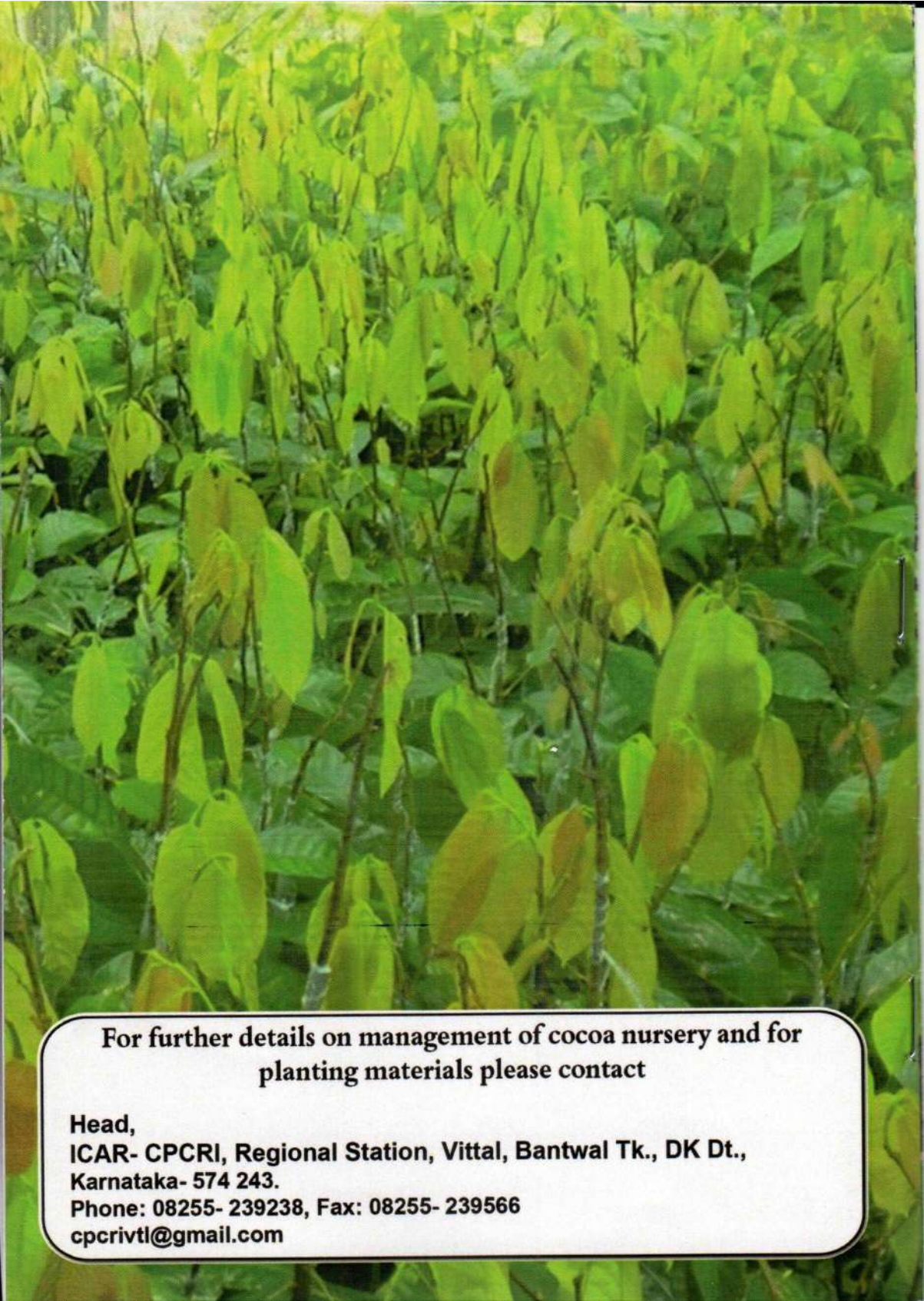
Free from nutrient deficiency / VSD

Quality tested : Good

CALENDAR ON NURSERY OPERATIONS







**For further details on management of cocoa nursery and for
planting materials please contact**

**Head,
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