

# **HAITI PRODUCTIVE LAND USE SYSTEMS PROJECT**

**USAID/Haiti Economic Growth Office**

**South-East Consortium for International Development  
and  
Auburn University**

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**Training Manual for Improving Cocoa Production  
in Haiti**

**by**

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## **PREFACE**

by Sarah K. Belfort, SECID Program Assistant

In early 1999, cacao specialist B.K. Matlick visited Haiti and suggested that farmers could be educated in simple cultural practices that would increase the yield of their trees by 20-30%. At the request of USAID, SECID developed a cacao yield improvement program based on B.K. Matlick's ideas. As part of the program, SECID engaged cacao production expert Chris Stevenson as consultant to provide technical assistance to partner organization (PADF and CARE) extension agronomists and local farmer groups in efficient cacao production techniques. Between March 1999 and November 2000 Mr. Stevenson made five working visits to Haiti. He focused on teaching correct pruning of cacao trees, grafting, and shade adjustment (thinning out the branches of overgrown shade trees to reduce shading from over 50% total shade to the desired range of 35%-50%). Details on Chris Stevenson's activities and the cacao yield improvement program can be found in SECID/PLUS semi-annual reports and in SECID/Auburn PLUS Report No. 48. A Creole-language cacao production booklet entitled "Annou Plante Kakawo Byen" was also produced by SECID in the context of this program. The present cacao manual gathers together all of the technical sheets that Mr. Stevenson included in his trip reports. It is hoped that the manual will serve as a valuable resource for project personnel and others interested in promoting cacao production in Haiti.

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## DEMONSTRATION PLOTS CURRICULA

### A. DETERMINE WHAT NEEDS TO BE DONE TO UPGRADE FIELD

Show cacao with management problems.

Show cacao with desirable and non-desirable characteristics.

Discuss strategies to increase production.

### B. REWORKING TREES FOR INCREASED PRODUCTION

**Select promising trees.** (to provide budwood)

- a. At or just before main harvest season select highest-producing trees on each plot or farmers field.
- b. Record the pod number in a notebook with location, and mark tree with flagging tape or paint.
- c. If need be select trees on neighbor farms when no superior trees are found on plot.

**Select lowest producers on demonstration plot.** (to be grafted)

- a. Mark trees (paint or tape).
- b. Grafting methods - on trunk or suckers.
- c. Training and practice of farmer and extensionist.
- d. After training of grafts:
  - (1) Thin out canopy and pruning of mature tree, staking of young tree.
  - (2) Training young grafted tree to production stage.
  - (3) Or Costa Rica method. Cut old tree above graft at 90 days.

## C. PRUNING

### **Discuss pruning.**

- a. Tree form.
- b. Reasons for pruning.
- c. Sanitation pruning.
- d. Maintenance pruning.

Demonstrate - elimination of suckers, on the trunk and principal branches.

Demonstrate - pruning of over-extended and inferior branches.

Demonstrate - the elimination of branches that are dead, infected or broken.

Demonstrate - large cuts with machete and saw.

Demonstrate - lowering the height of the tree.

Assign a tree to each participant to prune and then evaluate.

## D. SHADE ADJUSTMENT

Discuss reasons for shade and the management strategy.

Discuss relation of shade to nutrients and growth.

Discuss the elimination of shade trees by ringing or poisoning.

## NOTES on YIELD

- < A cacao tree needs 35 leaves more or less to produce 1 pod.
- <  $\text{Kgs dry beans per area} = \text{number of trees per area} \times \text{number of pods harvested per tree} \times \text{number of beans per pod} \times \text{beans weight}$ .
- <  $\text{Pod index} = \text{number of pods} / \text{Kg dry beans}$ .
- <  $\text{Bean index} = \text{number of dry beans} / 100 \text{ grams}$ .
- < Yield increases:
  - Shade thinning ... immediate effect
  - Pruning ... effect in 6 months to 2 years
  - Grafting ... 1.5 to 3 years, best long-term effect
- < Harvest frequently, once a week if possible. This may help decrease losses due to rats and disease.

### **Things to avoid:**

- < Do not pull, twist off or otherwise damage the flower cushions. These damaged cushions often will not produce flowers thus no pods. Therefore harvest cacao pods by cutting them.
- < Do not cut the tree unnecessarily.
- < When pruning avoid tearing the bark.
- < Do not dry cacao on metal. This will produce black beans.

## **PRUNING**

### **Limiting tree height:**

1. The leaf canopy should be about 4 to 5 feet (1.2-1.5 m) thick with a maximum height of 15 feet (4.5 m) (2). In lowering tree height, cut upright branches on the top of the tree to one-half their height. Repeat a year later or for several years on an annual basis until height has been brought down to 4 to 5 meters.
2. Another system would be to bring the trees down in one cutting. For demonstration purposes we will do this pruning at one time on non-producing cacao trees.
3. After bringing the trees down, one should prune lightly two or three times a year. The aim will be to:
  - (a) maintain height,
  - (b) trim branches that are turning down into the middle of the row,
  - (c) trim dead branches,
  - (d) trim crossing branches in the middle of the tree, and
  - (e) remove suckers.

### **Timing:**

1. End of dry season and before main flush.
2. End of main harvest.
3. Before main pod setting period and not during main pod developing phase. Try to balance these though all may not be possible.
4. Not during flushing periods. The leaves should be mature (1).

### **Sucker pruning:**

1. Every time you harvest prune suckers. If there is no harvest for a month, then do a sucker pruning cycle.
2. Prune suckers from trunk and main branches.

### **Sanitation pruning:**

At the end of the main harvest prune out dead branches, epiphytes, climbing plants, old, diseased and overripe pods.

## **Technique :**

1. Around the base of every branch is a swelling known as a collar. Within it is the protective zone of the branch, that is, the place where the branch's chemical defenses are established. The collar should not be injured or removed by pruning (3).
2. Cuts should be made in such a way that rain can run off easily (1).
3. All tools should be sharp. They generally consist of pruning knives, cutlasses, saws, hand pruners, and lopping shears.

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- (1) Dominquez, M.A., Pruning, 1984, International Training on Technique in Cocoa Production in Belize.
- (2) Lopez, A., Pruning - Recommended Plantation Policy, In-House Paper, 1985.
- (3) Shigo, A.L., Compartmentalization of Decay in Trees, 1985, Scientific American, pp. 96-103.

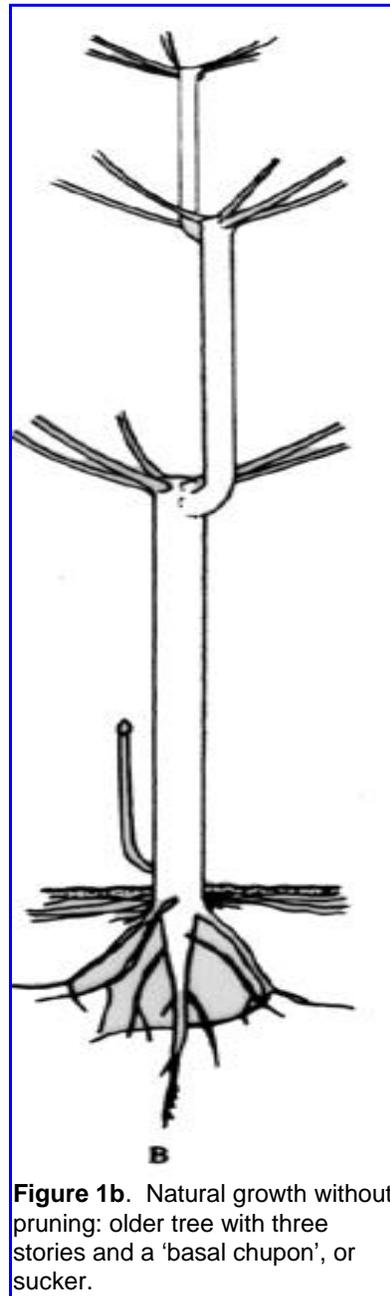
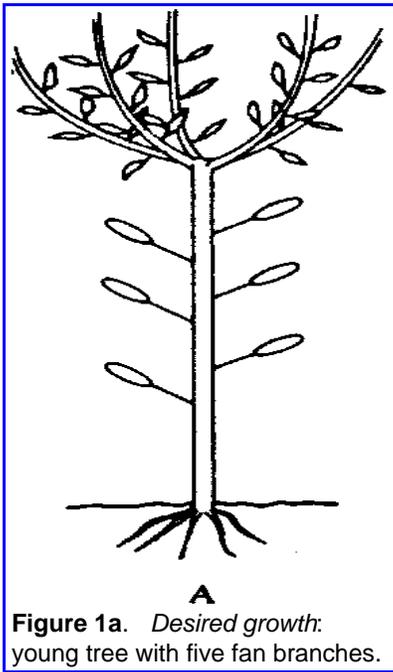
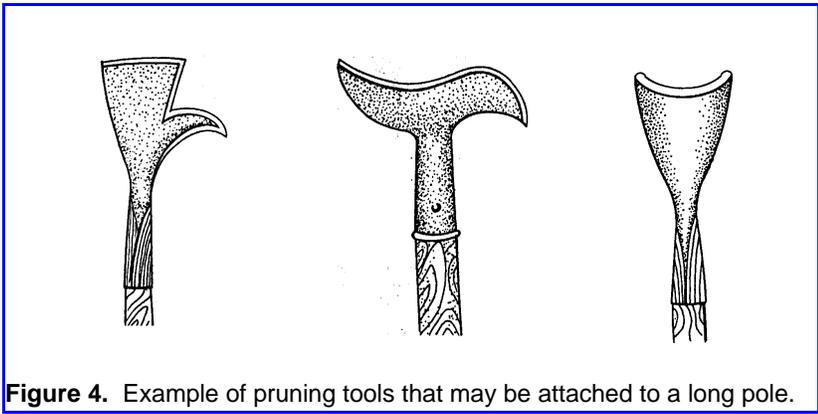
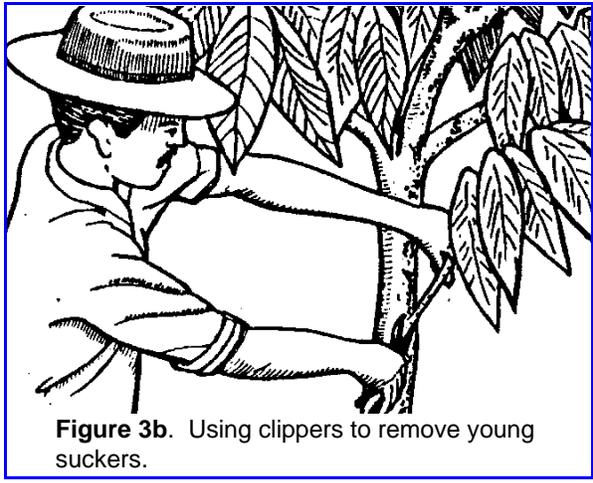
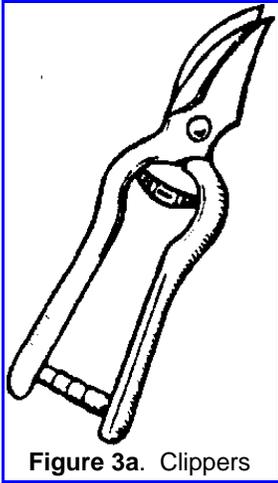




Figure 2. Pruning of suckers from a well-managed tree.



Before



After: correct canopy



After: incorrect canopy



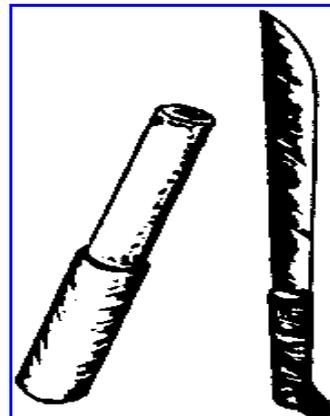
Figure 5. Samples of correct and incorrect canopy.



**Figure 6a.** Using a machete and wooden mallet to prune larger branches or suckers.



**Figure 6b.** Sample use of a machete and wooden mallet to prune suckers or branches.



**Figure 6c.** Sample mallet and machete tools.

## GRAFTING (BUDDING)

### **TREE SELECTION**

1. Choose trees with 30 or more pods during one harvest season.
2. Mark trees and note tree location.
3. Data is to be taken over time and should be kept on file.
  - a. Number of pods to produce 1 kilo of dry beans.
    - (1) Weigh wet beans from a number of pods from selected tree and multiply by 38% to get estimated dry weight.
    - (2) Calculate number of pods to equal 1 kilo dry weight.
    - (3) This is the pod index.
  - b. By counting determine the number of beans per pod (average) for the selected tree.
  - c. Also note number of pods harvested by month.
4. Trees chosen can be from the demonstration plot, outside the plot, or from other farms.
5. Good-producing trees will be used as mother trees for mature tree budding.

Trees with few or no pods will be considered unproductive. They will be marked for grafting and major pruning.

# **MATURE BUDDING PROGRAM**

## **Introduction**

1. In a typical cacao field 30% of trees produce 70% of the production.
2. Trees are not uniform.
3. Need to first determine reason for low yields; i.e. drainage, overshadowing, fertility, etc.

## **Program**

1. Select low- or non-producing trees.
  - a. Mark trees (different from superior trees).
2. Replacement strategies.
  - a. Bud very low producers first.
  - b. Check medium-level producers second year to see if there is improvement and mark again. Then decide whether or not to bud.
3. Budding methods.
  - a. Closed Method (on trunk)
    - < A horizontal cut of about 6-8 mm is made into the trunk to cambium depth.
    - < The bark is then carefully peeled upward to expose a panel of cambium, 6-8 mm wide and 3-4 cm long, for receiving the bud patch.
    - < A bud patch narrower than the fresh exposed stock panel is placed against it. The bud on the patch should be above the petiole against it.
    - < Strict cleanliness should be practiced to avoid any possible contamination with soil or other matter on the cambial surfaces.
    - < Once the bud patch is placed against the freshly exposed stock panel, it is closed up by reinstating the bark flap to its original position with the help of the budding tape.

- < In this method it is important to ensure that the petiole remnant is taller than the bud when reinstating the bark flap.
- < The bud patch is positioned firmly against the stock panel by means of budding tape (2.5 cm wide).
- < Binding starts below the panel and the tape is wound clockwise and upwards; each turn overlaps the preceding one to ensure satisfactory seal.
- < Timing of budding tape removal = 10-15 days.
- < Budwood taken from softwood budsticks. In our case use chupon buds (orthotropic) if possible as these will produce a normal tree.

**Tips:**

- a. Use masking tape above the graft as additional protection against water infiltration.
- b. Make 3 buddings on the same tree to insure success.
- c. After bud release make a 5-cm wide, ½ -cm high cut on the trunk, 2 cm above the bud.
- d. One month after budding stake the new shoot.
- e. Two months after budding, prune the tree above the bud graft.
- f. At three months eliminate the tree to just above the bud graft.

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Mohd. Jelani Bahaudin, A. Raub Maulud, and Aleham Hambali, Evaluation of several mature budding techniques of cocoa. Proceedings International Conference on Cacao & Coconuts. pp.147-156, Kuala Lumpur, 15 - 17 Oct. 1984.

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## **BUDDING BASAL CHUPONS (PATCH BUDDING)**

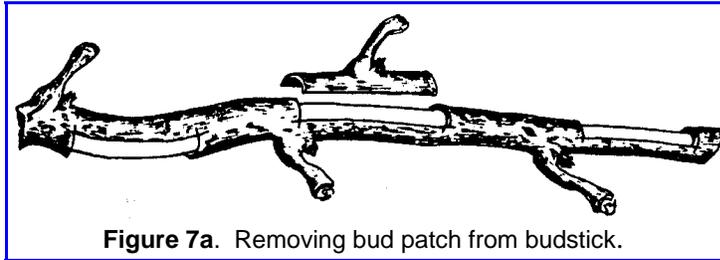
1. In the chupon to be budded make a 3-4 mm horizontal cut to cambium depth. Make two parallel vertical cuts 3-4 cm long. Peel carefully down to expose a panel of cambium 3-4 mm wide and 3-4 cm long. Trim the flap to 1 cm length to provide a tongue to help hold the budpatch in place.
2. A budpatch narrower than the exposed stock panel and with a centrally located bud about 2 cm from its lower extremity is removed carefully from a budstick.
3. The budpatch is placed at once against the exposed panel. Cambial surfaces must not be handled or subjected to lateral or vertical pressures.
4. With the budpatch positioned, its upper extremity is then trimmed to ensure it fits snugly into the stock panel and the remnant of the leaf petiole is pruned back almost flush with the bark surface.
5. Binding starts below the tongue and the tape is wound clockwise and upwards, each turn overlapping the preceding one to ensure satisfactory seal.
6. In patch budding, a maximum of one third of the circumference of the rootstock bark is cut open.
7. In patch budding, a 1 mm space between the sides of the budpatch and the "window" of the rootstock will allow callus growth.
8. The budding tape is released 14 days after budding.
9. After the tape release, the stocks are topped to allow 4 to 8 leaves be left above the patch. A maximum of 6 inches (15cm) of stock remain above the budpatch.

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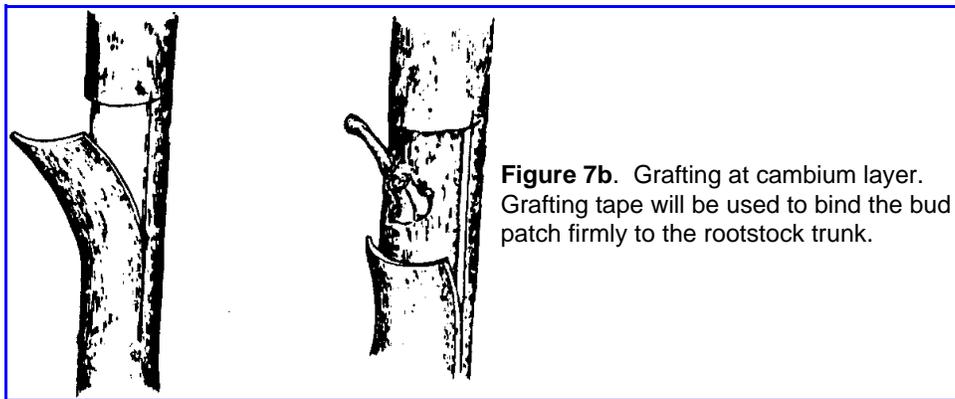
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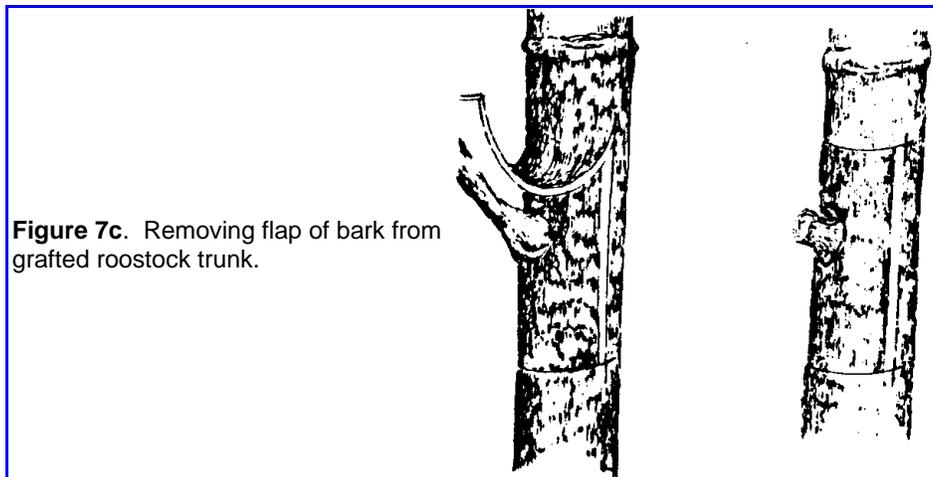
Shepherd, R., C.F. Chong & J.G. Taylor, Experiences with Nursery Budgrafting on Cocoa Estates in Malaysia.



**Figure 7a.** Removing bud patch from budstick.



**Figure 7b.** Grafting at cambium layer. Grafting tape will be used to bind the bud patch firmly to the rootstock trunk.



**Figure 7c.** Removing flap of bark from grafted rootstock trunk.

## **BASAL CHUPON REHABILITATION METHOD**

Rehabilitation of trees by chupon replacement can be considered when productive trees get old and too tall. Chupon replacement is a useful technique widely adopted in many cacao-growing areas. In this method a basal chupon is selected to grow from the base of the tree at ground level. An independent root system is encouraged by heaping soil at the base of the new tree. Pruning of the old tree is done periodically over the next 3 to 4 years. The chupon should produce a jorquet (crown) at a height about 1.5 meters. The new tree is then trained in a normal way. With adequate care, it will bear fruit after about two years. The old tree is removed in the 4th year.

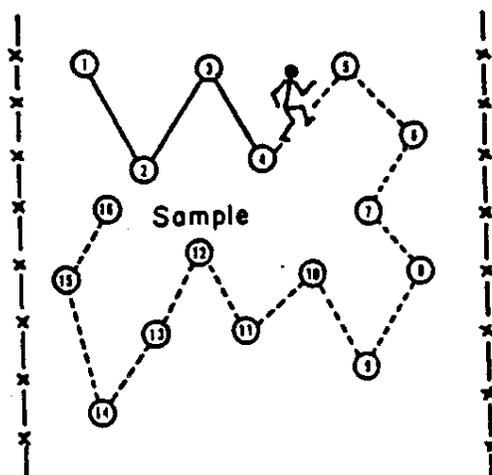
For this method chupons can be encouraged by making a cut 3 inches wide, 1 inch tall, and 1 inch deep at the base of the old tree.

One thing to remember is that when pruning you are 1) removing part of the old tree, and 2) adjusting the shade for the new tree.

This method can be used with old non-productive trees in combination with grafting. Budding on chupons has a high success rate.

## COLLECTING SOIL SAMPLES FOR CACAO

1. Take one composite sample made up of 16 subsamples per block. Thus, 16 subsamples will be taken in one block and mixed together to make the one composite sample for that block.
2. Take samples from between the rows of cacao.
3. Do not take samples from unusual areas such as under trees, near rocks, next to drainage ditches, or within 20 feet of roads.
4. Also, do not sample soils within the block that will not be used for cacao, i.e. ridges, land to be used for citrus, etc.
5. Remove litter from subsample site.
6. Dig a V-shaped hole 8 inches deep with a spade and cut a ½-inch-thick slice of soil from the face of the hole.
7. Take about a 1-inch strip top to bottom from the middle of the spade. Place this strip of soil in a clean pail. Do Numbers 5 through 7 for a total of 16 times within the block.
8. Break up and mix the soil taken from the 16 sites in the block. Fill the soil test container and discard the remainder.
9. Number the samples and keep a record of sample taken.
10. Avoid sampling the soil when it is very wet.





### **C. Materials for Nursery Construction**

1. Material should be available locally.
2. Material needed:
  - a. Wood posts 7½ to 10' long.
  - b. Palm fronds or other suitable material to provide shade. Palm fronds are preferred because it is easy to adjust shade during the nursery phase of the seedlings.

### **D. Nursery Construction**

1. The site chosen for nursery construction should be cleared, levelled and free of weeds.
2. Provision must be made to drain the nursery. High humidity inside the nursery due to the extra water will be a good environment for *Phytophthora*.
3. Dig holes at 10 ft (3 m) spacing across the length and width of the site. Erect wood posts 1 ½' deep in the ground for firm support of the roof.
4. Connect wire or wooden strips to the top of the post to support the palm fronds or other materials.

### **E. Shade**

Shade may be provided by thatch or trees. Thatch in the form of palm fronds may be the best shade available because as it deteriorates, it allows more light to reach the cacao seedlings. When the seedling emerges, it requires about 75% shade, but by the time it is ready to transplant into the field, the shade requirement is about 50%. A reduction in nursery shade is necessary to harden the seedlings for the field.

### **F. Potting**

1. Potting bags
  - a. It is recommended to plant seeds directly in the bag.
  - b. Bag size depends on the duration seedlings will be in the nursery. The following criteria can be used to determine the bag size:

**Table 1. DIMENSIONS**

<b><u>MONTHS IN THE NURSERY</u></b>	<b>Length Inches</b>	<b>Width Inches</b>	<b>Gauge (Unit)</b>	<b>Color</b>	<b>Weight of Bag &amp; Soil Kg</b>
<b>Greater than 3</b>	<b>10</b>	<b>7</b>	<b>150</b>	<b>Black</b>	<b>2.7</b>
<b>4 to 5</b>	<b>12</b>	<b>8</b>	<b>200</b>	<b>Black</b>	<b>4.5</b>
<b>Less than 6</b>	<b>15</b>	<b>9</b>	<b>250</b>	<b>Black</b>	<b>6.8</b>
<b>Greater than 6</b>	<b>16</b>	<b>10</b>	<b>250</b>	<b>Black</b>	<b>9.0</b>

c. Plastic bags with perforations are preferred because they are:

- (1) durable
- (2) easy to maintain
- (3) will provide drainage and keep the soil moist enough for good seedling growth.

d. Bags must be durable and able to withstand the hazards of transportation and wear and tear if the seedlings are to remain more than 4 months in the nursery.

## 2. Potting Soil

a. Top soil which can supply all the major and minor nutrient elements for a period of 45 - 60 days and with good texture and structure should be used.

b. pH of the soil should range 5.5 to 6.5.

c. If available soil is a heavy clay loam or is low in organic matter, then add the following:

- (1) 20% by volume coarse sand from the river, **or**
- (2) 20% by volume well-rotted organic matter.

d. If the soil is poor in nutrients (determined by soil analysis), then add 10 -15 g of CaO to each bag of size 30 cm x 20 cm. This would supply calcium and also raise soil pH if it is less than 5.5. Add 10 g of complete fertilizer containing 12-24-12 NPK to each bag of size 30 cm x 20 cm if the soil is deficient in the major elements.

e. Soil must be free from lumps, stones, sticks, etc. before filling the bags.

### 3. Filling and Arranging of Bags

If the soil to be used for the nursery meets the specifications described above then fill the bags with this soil to capacity.

Bags must be arranged in beds of 2.5 to 3 ft. widths. Length of bed is equal to the length of the nursery. Leave an access path of 1.5 ft. between each bed. The access path is necessary for the movement of the operators who will perform cultural practices.

**Table 2. Filling and arranging of Bags**

2.5 - 3 ft.				1.5 ft.	2.5 - 3 ft.			
<b>CACAO SEEDLINGS</b>				<b>ACCES S  PATH</b>	<b>CACAO SEEDLINGS</b>			
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x
x	x	x	x		x	x	x	x

### G. Selection of Pods to Extract Seeds for Planting In Nursery

1. Pods 3 to 4 weeks from harvesting can be selected for seed.
  - a. This will result in seedlings with maximum vigor and foliage production.
  - b. Pods at this stage will be full grown - approximate length and width of the pod at this time will be 6" and 3", respectively. Color of the pod at this stage is green or red depending on the type. The pods are full grown but have not started changing color.
2. Number of pods required can be calculated by dividing number of seeds required by 30 (assuming each pod on an average will yield 30 seeds).

3. Always harvest more pods than calculated in No. 2.
4. Harvest the pods for seed at least 2 to 3 days before planting.

#### **H. Preparation of Seeds Before Planting**

1. Extract the seed from the selected pods.
2. Select seeds which are healthy and mature.
3. Mix seeds with sawdust or very fine sand.
4. Rub seeds and sawdust or fine sand thoroughly and then wash with water. Repeat the process until most of the mucilage is removed from the seed. More sawdust or fine sand is mixed with the seeds each time the process of rubbing is repeated.
5. The process of mucilage removal must be done carefully so as not to damage the growing point of the seed.

#### **I. Planting the Seeds**

1. Plant seeds with the longest part down around one centimeter deep in the soil. If you can not determine the longest part, then plant the seed on its side.
2. Cover the rest with the sawdust. It will take 2 - 3 weeks, depending on the temperature, for the seedlings to emerge.

#### **J. Maintenance - Water Application**

1. During the dry season, water the seedlings at least twice a week.
2. Avoid daily watering. This can result in reduce growth and produce mineral deficient seedlings.
3. During the rainy season, it is not necessary to water the seedlings if enough water reaches the bags via the overhead palm fronds. This can be determined by feeling the soil surface of randomly selected bags in different sections of the nursery. If the surface of the majority of the bags are moist, there is no need to apply water.

#### **K. Fertilizer Application**

If the soil used in the nursery meets the criteria described before, then fertilizer use can be minimized. The following recommendation will effectively rectify the mineral deficiencies in the nursery.

If after two months from planting, the seedlings show signs of macronutrient (NPK) deficiency, then treat each bag with 10 g. of complete fertilizer (12-24-12 or 10-15-10).

## L. Diseases in the Nursery

### 1. *Phytophthora palmivora*

#### a. Symptoms of seedling blight

- (1) Leaves develop wet brown spots and then dry up.
- (2) Stem goes black, and in advanced stages the stem dries up and twists to form a hook.

#### b. Control measures

- (1) Eliminate the infected plants.
- (2) Infection of cacao with *Phytophthora* is an indication of too much shade and /or poor drainage. Adjust the shade of the nursery according to the age of the seedlings.
- (3) As a preventive measure, spray with copper or kocide® at the rate of 10 oz. of kocide® per 2½ gallons of water every two weeks; 2½ gallons of solution will be enough to spray 2,500 seedlings.

### 2. Anthracnose (*Colletotrichum galloesporioides*)

#### a. Symptoms of anthracnose

- (1) Brown wrinkled lesions on young leaves appear as the seedlings grow.
- (2) Leaves turn dull green and then gradually yellow, wither, and die.
- (3) Heavy infection can result in defoliation of the shoots. Repeated defoliation may initiate the development of side shoots.

## M. Plant Selection

When the seedlings are ready to be planted on the permanent site, then cull seedlings which have:

1. Seedling blight.
2. Defoliated seedlings due to insect attack.

3. Weak stems, underdeveloped leaves, small number of leaves and those that appear to be runts.

**IT IS ESSENTIAL THAT ONE PLANT AT LEAST 20% MORE SEEDS THAN THE NUMBER OF SEEDLINGS REQUIRED FOR THE FIELD.**

#### **N. Budding (Grafting)**

Budding involves patching a scion or budwood from a selected tree of superior genetic source to a root stock.

##### 1. Advantages

a. It is the most convenient method of propagating selected high yielding, disease and insect resistant material compared to hand pollination.

##### 2. Growing and maintenance of root stock

a. Root stock seeds are grown in the nursery and are maintained as described above.

b. Root stock seeds must be healthy in order to become vigorous seedlings. This will result in plants ready for budding in 2½ to 3 months from emergence.

c. Root stock selection should pass through the same criteria as described above.

3. Budding can be done either when the root stocks are still in the nursery or when they are planted in the field. Advantages of budding in the nursery are:

a. Root stocks can be looked after easily for:

- (1) watering,
- (2) control of diseases and insects, and
- (3) fertilizer application.

b. Percentage of "take" is higher if budding is done in the nursery.

c. Strain of the budding operation is less in the nursery than in the field. The operation is also better organized and more efficient.

##### 4. Selecting budwood or scions

a. Budwood should be selected from healthy trees.

b. The tree should not be flowering when budwood is selected; this could reduce the food supply for the tree during a critical period.

c. Budwood from chupons is preferred because it will produce a tree which does not require extensive pruning in the first few years.

d. Budwood selected from a fan branch will produce a bushy tree that will require extensive pruning and training.

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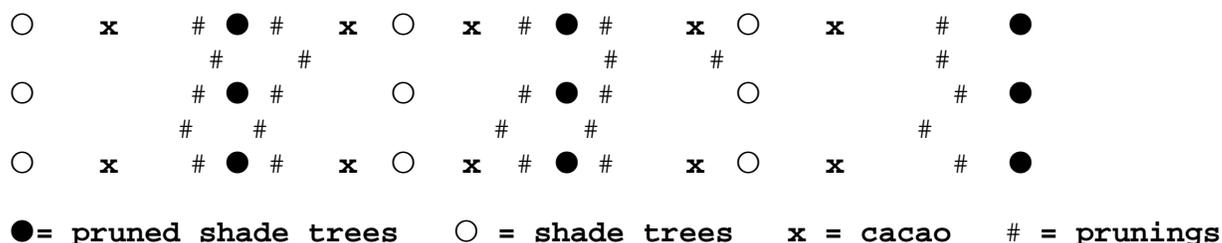
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*Reference*

COCOA MANUAL, by Khan, Mir N., Gordon Patterson and Christopher Stevenson

## INTENSIVE AGROFORESTRY CACAO ESTABLISHMENT

1. Between row planting of *Gliricidia sepium* or *Leucaena*.
2. Legumes planted half of cacao spacing between the cacao rows.  
(Cacao 10' x 10', shade 5' x 10')
3. Prune legume at a height just a little higher than the cacao and only every other row of shade trees.
4. When the pruned row of shade rows grows back prune the alternate rows.
5. The prunings are used for mulch.



**Table 3. Dry matter and macronutrients from *Gliricidia sepium* and *Leucaena leucocephala* periodically pruned and planted with cacao.**

	<i>Gliricidia</i>	<i>Leucena</i>
	Kg/ha /Year	Kg/ha /Year
N	376	339
P	34	26
K	391	324
Ca	133	65
Mg	82	36
Dry matter: leaves	8,127	7,494
Total	18,223	15,321

## **Management of Shade Trees**

Densely planted temporary shade of *Gliricidia* or *Leucaena* (2,222/ha) are established between the cacao rows at 1.5 m between trees.

Alternating rows of shade trees are pruned lightly to the level of the tops of the cacao seedlings.

The prunings are used as mulch for the cacao.

The alternating non-pruned row of shade trees furnish shade while the pruned trees recover. When the pruned rows have recovered and begin to excessively shade the cacao seedlings it is time to prune the alternating unpruned rows.

This practice continues every 8 - 12 weeks and goes on for about 3 years.

After three years the removal of the temporary shade begins at the rate of 25% a year.

The advantage of this system is to intensify nutrient recycling, greater weed control and good management of the new cacao



### Simple Provisional System

1. First plane or level = banana or plantain.
2. Second plane = pigeon pea, papaya, castor, cassava, and cocoyam.
3. Legumes that can be used = *Crotalaria*, *Tephosia*, *Gliricidia* and *Leucaena*.

### Multiple Provisional Systems

These systems use food crops in the cacao row:

Plantain, banana, pigeon pea, papaya;  
also tall castor, *Gliricidia*, *Leucaena*

Crops for between rows:

Corn, cassava, okra, red pepper, rice, beans and cowpeas, peanuts, sweet potatoes.

These can be followed by shade-tolerant pumpkin and yams.

### Provisional Hedgerow System

Single or double row cacao with 10 m between rows for cultivation of food crops.

### Perennial Mixtures Systems

Coconut 8 m x 8 m with cacao in double rows at 3 m x 2 m.

1. Dwarf coconut at 6.4 m x 6.4 m.
2. Plant cacao when coconut is three years old.
3. Cacao spacing in row:

- a. 3.2 m = 550
- b. 2.1 m = 830
- c. 1.6 m = 1107

*production in 5 years*

- a= 580 kg/ha
- b= 753 kg/ha
- c= 1019 kg/ha

Provisional shade under coconut:

*Sesbania punctata*, *cjanus cajan*, *Gliricidia sepium* or *Leucaena*

Other;

Single row of cacao between rows of cloves (spaced 8 m x 8 m or 10 m x 10 m).

Peach Palm (*Bactris gasipaes*) at 20' x 20' with cacao at 10' x 10'.

### Sequential Multiple Cropping

Various intercropping with temporary and permanent crops.

India:

H = pineapple    ' = black pepper on area    x = cacao

J  
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### Perennial Hedgerow Mixtures

1. Wind breaks:
 

Mangos	Coconuts
Cloves	Peach Palm
Legume trees	Forest trees
2. Hedge rows forming "boxes" of two acres of cacao.
3. Perennial boundary

Mangos - Grenada	Cloves - Fiji
Mahogany	

### Some Agroforestry systems practiced or suggested for cacao.

Reference – R. Alvim, 1987- International Cocoa Conference.

# A

```
x      x          x      x      x      x
      o          o          o
x      x          x      x      x      x
      o          o          o
x      x          x      x      x      x
```

Continuous    o = shade tree    x = cacao (ie cacao & peach palm)

# B

```
o      o          o      o      o      o
      x      x      x      x      x
o      o          o      o      o      o
      x      x      x      x      x
o      o          o      o      o      o
```

Continuous    o = shade tree    x = cacao (ie cacao & areca)

# C

```
o o      x x x o o x x x o
```

```

o o      x  x  x  o  o  x  x  x  o
o o      x  x  x  o  o  x  x  x  o
o o      x  x  x  o  o  x  x  x  o
Zonal System    o = shade tree  x = cacao

```

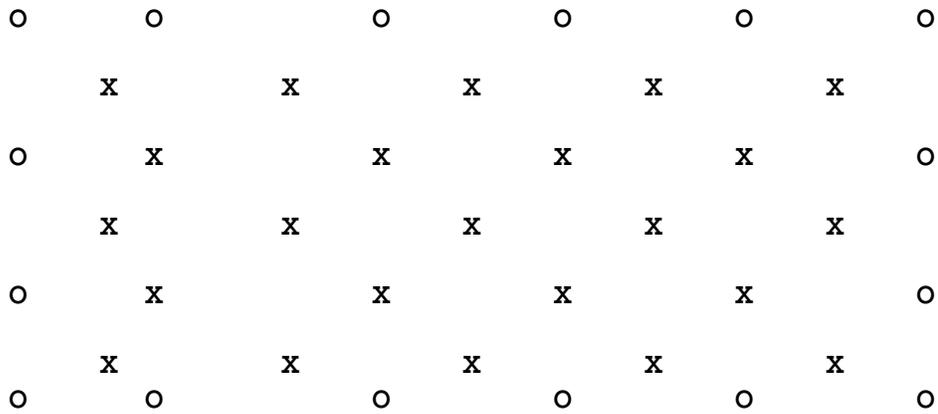
## D

```

o      o      o      o      o      o
o      o      x      o      x      o      x      o      o
o      o      x      x      x      x      x      o      x
o      o      x      x      x      x      x      o      o
o      o      x      x      x      x      x      o      o
o      o      x      x      x      x      x      o      o
o      o      o      o      o      o      o      o      o
o      o      o      o      o      o      o      o      o
Zonal System    o = shade tree (rubber)  x = cacao

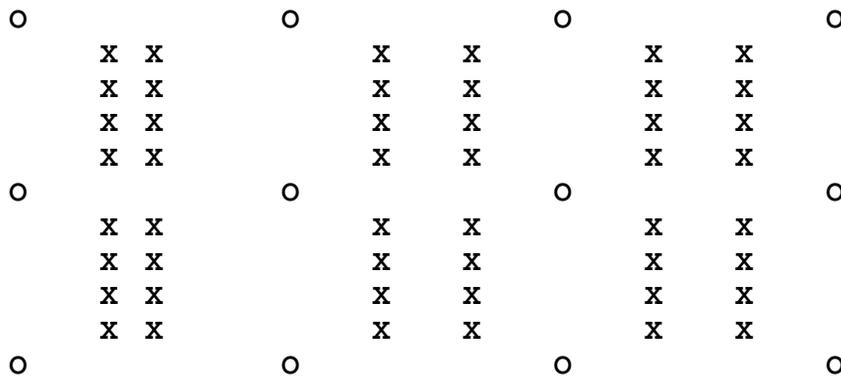
```

## E



Zonal System    o = shade trees as wind break    x = cacao

## F



Zonal System    o = shade trees -coconut    x = cacao

(1) Cacao is normally cultivated in intimate association with other species, such as food crops and taller trees, which, respectively, provide temporary and permanent shade to protect the crop during its juvenile and productive phases. When cacao is combined with species which provide additional economic outputs and/or introduce ecological benefits into the system, the practice is designated **agrosilvicultural**. Several multiple land management systems have been used with cacao as the primary crop. These include: (1) temporary taungya-like systems (using *Musa paradisiaca* and *Colocasia antiquorum* as the second layer); (2) simple temporary systems (with *M. paradisiaca* in the second layer, and species such as *Cajanus cajan*, *Carica papaya*, *M. textilis*, *Sesbania punctata*, *Tephrosia candida*, *T. vogelli* [*T. vogelii*], *Leucaena*

*leucocephala*, *Gliricidia sepium* or *Flemingia macrophylla*/*F. congesta* in the third layer); (3) multiple temporary systems (with various food crop species in the second layer providing lateral shade, and species such as *Piper nigrum* and bananas, or permanent shade trees in the third layer); (4) temporary hedgerow systems; (5) perennial mixtures, e.g. cacao and coconut (*Cocos nucifera*) or oil palms (*Elaeis guineensis*), rubber (*Hevea brasiliensis*), cloves (*Syzygium aromaticum*), peach palms (*Bactris gasipaes*) or Brazil nuts (*Bertholletia excelsa*); (6) perennial hedgerow mixtures; (7) perennial boundary cropping (using *Mangifera indica*, *Calophyllum antillanum*, *S. aromaticum*, *Eugenia malaccensis*, *Swietenia macrophylla* or *Cinnamomum zeylanicum*); and (8) sequential multiple cropping (involving pineapples (*Ananas comosus*), species such as *L. leucocephala*, *G. sepium* and *Erythrina fusca* used as support trees for peppers, and *F. macrophylla*).

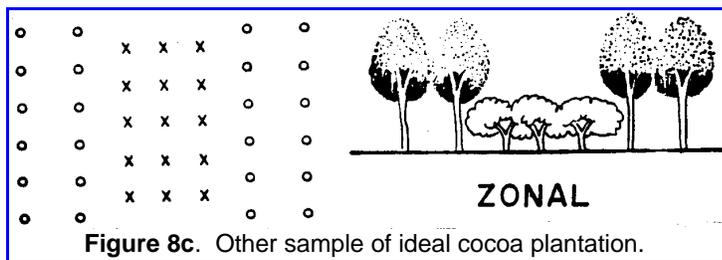
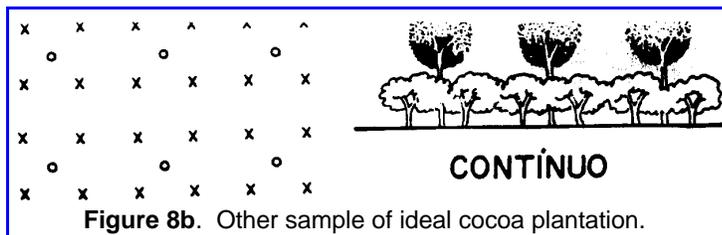
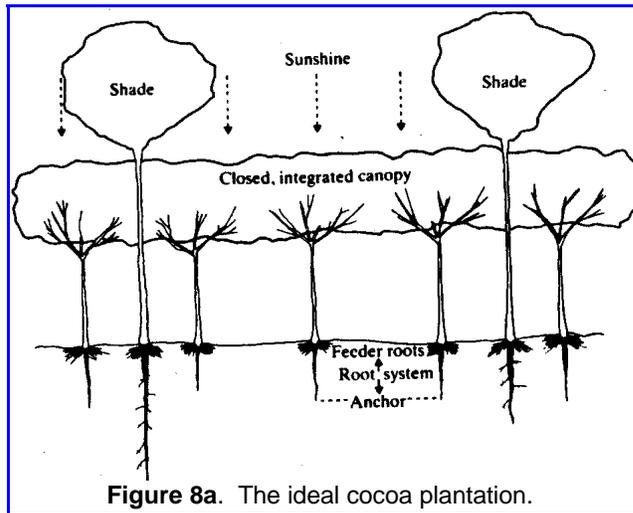
Tan et al (2) found that cacao planted with papaya was highly advantageous. The economic benefit from using papaya to replace 86% of the conventional *Gliricidia* stand was \$1389/ha. Cacao under papaya shade yielded 415 g wet beans/tree at two years of age, compared with 372 g wet beans/tree under 100% *Gliricidia*. Twenty-four months after planting, 81.6% of cacao trees under papaya shade were either flowering or cherrille bearing, compared with 68.5% under *Gliricidia*.

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#### References

- (1) Alvim, R., Cacao (*Theobroma cacao*) in agrosilvicultural systems. Agrotropica. 1989, 1: 2, 89-103; 29 ref.
- (2) Tan, CH; Chan, CL; Tay, SP, Commercial establishment of papaya intercropping with cocoa - Asiatic experience. Planter. 1991, 67: 784, 301-313; 3 ref., 2 pl.



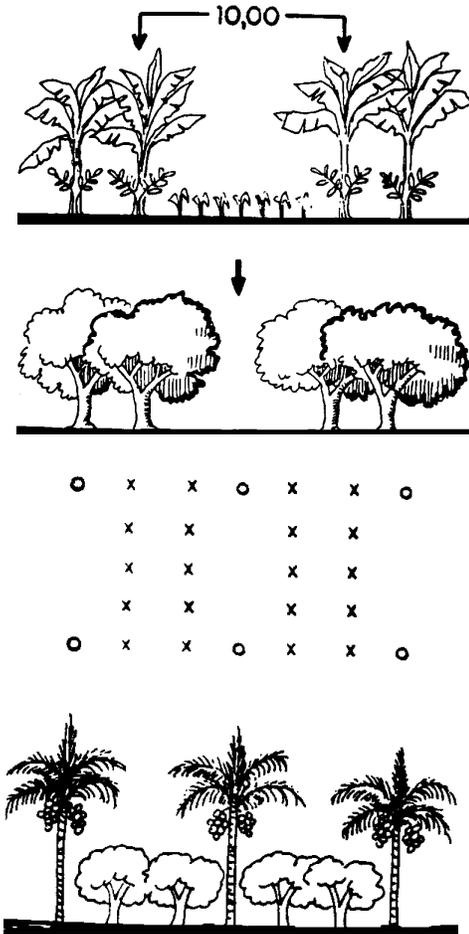


Figure 9. Zonal System

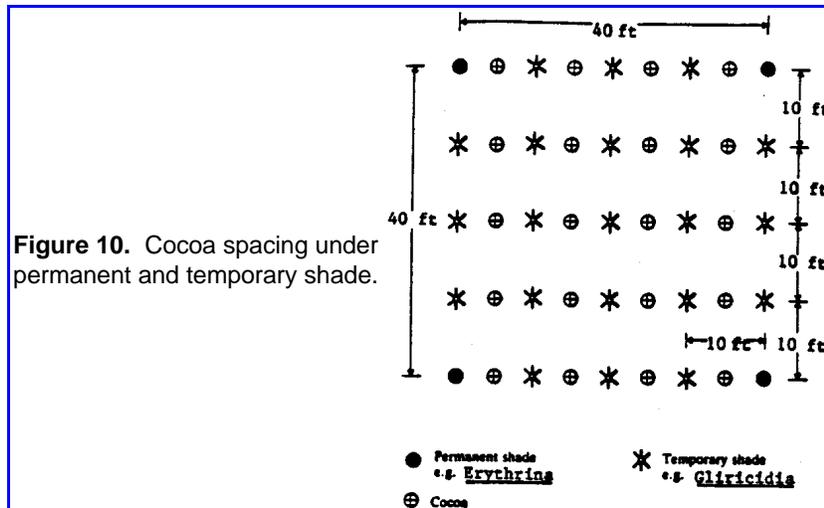


Figure 10. Cocoa spacing under permanent and temporary shade.

## **PLANTING CACAO**

Planting should ideally be done at the beginning of the rainy season and up to 3 months before the dry season. This will give the young plants a chance to get a vigorous start. Also the shade in the field should be similar to that in the nursery (about 50%).

Control weeds. Start the cacao growing without any competition from weeds.

After arrival at the field, the plants are distributed to the planting stakes. It is best to receive at the field the amount of plants that will be set out and planted the same day. Otherwise plants may be laying about overnight and be subject to damage or theft.

Currently it is recommended to dig a hole just large enough to receive the seedling. This is also usually done on the day the seedlings are planted.

Planting consists of removing the polyethylene bag, placing the seedling in the hole and filling in soil around the plant. This may best be done by ripping or cutting the sides of the bag, placing the seedling in the hole and gently remove the bag. Then push soil into the hole filling it. Press the soil around the plant as you go until it is firm. It is recommended not to leave a depression around the plant as this may collect too much water and cause problems.

If budded seedlings are planted, they will have to be staked. The stakes should be a minimum of 5 feet tall when placed in the ground. The growing branch from the patch bud will be tied to and trained to grow up the stake. The branch should be tied securely but loosely to the stake.

If some seedlings do not have adequate shade, some form of artificial or temporary shade can be made. This is usually done using palm leaves placed on a platform made from sticks over the cacao seedling. This must be checked periodically to see that it has not fallen. As soon as there is regular shade this artificial arrangement should be taken down.

After two weeks the field should be checked for seedling mortality which is usually 5%-10%. Seedlings that are definitely not doing well should be eliminated. The following week the missing and weak trees can be replaced. After 3 to 4 weeks the seedlings will be over planting shock and will be flushing regularly. After the first flush has hardened, field budding can be done if that is the program.

## FIRST YEAR MAINTENANCE TECHNICAL SHEET

**1. Weed Control:** It is in the first year after establishment that weeds can cause the greatest damage to cacao. Their control is necessary if satisfactory growth is to be encouraged and maintained.

For the first 6 months, a circle 3 feet in diameter must be kept clean around each cacao plant. This should be done with a hoe except for the area right up against the stem. Cleaning by the stem should be done by hand pulling of the weeds. The areas between rows can be cut using a machete or herbicides. Care must be used to avoid herbicide contact with the cacao. The use of shields is recommended. When bark on the seedlings turns brown at approximately 6 months after planting, then herbicides can be used around the cacao seedlings, but avoid contact with green tissue. Herbicides that can be used during the first year are paraquat and glyphosate.

The number of times these measures will be needed will depend on the amount of shade and weed vigor.

Mulching may be practical in some areas. Clear a circle (2 - 3 feet across) around each seedling and remove all weeds. Cover this area with mulch until one foot thick. Leave a clear space around the stem to help avoid pests and disease. Additional mulch must be added every 2 to 3 months.

**2. Fertilizing:** Young cacao should be fertilized by hand and by tree. Two weeks after planting, two ounces of a nitrogen fertilizer may be applied per seedling. One month after planting, start applying a complete fertilizer at the rate of 2 ounces per plant. This complete fertilizer should reflect the findings of a soil analysis. Make 4 fertilizer applications the first year of 2 ounces per application per plant. Apply the fertilizer in a ring around the seedling at a distance of between 4 inches to 2 feet from the main stem of the seedling. Make sure there are no weeds present prior to applying fertilizer. Weeds will use the fertilizer before the cacao can.

**3. Pest Control:** The chief pests during the first year will probably be leaf cutting ants, pinhole borer or ambrosia beetles, longhorn beetles, and possibly thrips.

**a. Leaf cutting ants** (i.e., *Atta cephalotes*) will defoliate young trees and seedlings. They cut and carry off roundish pieces of leaf to their nests. On these leaf pieces they raise a fungus which they eat. They can defoliate a seedling leaving only the principal leaf vein on the seedling.

**b. Pinhole borers**, also called ambrosia beetles (*Xyleborus* sp.), can kill young seedlings. The larvae bore into the young stems making very tiny holes. If the leaves of seedlings suddenly dry up, check for small holes on the stem. They seem to attack primarily when the seedlings are under stress, i.e. dry season. When the seedlings are actively growing they have more resistance.

**c. Stem borers** (Cerambycidae) may be a problem in the first year. The larvae eat the underside of the bark and may ring the stem or destroy the growing point.

**d. Thrips** (*Selenothrips rubrocinctus*) when numerous can cause defoliation. When you note the leaves with numerous necrotic areas, look to see if there are thrips present. They will occur in areas with insufficient shade. Correct the shade and if the area under attack is large, spray Sevin® or Malathion® with 3 sprays at 15 - 20 day intervals. Chemical control is as follows:

Sevin®	400cc/100 liters of water
Malathion® 50E	400cc/100 liters of water

**e. Caterpillars** may appear at various times. If the areas under attack are large enough to justify spraying apply Sevin® (see **d** above) or Dipterex®. One or two sprays will probably be enough.

**f.** Various species of **Monalonion** constitute pests of primary importance in Central America. They are agile, of a delicate appearance and 10 mm in length when adult. Generally the head, wings and at times the feet are dark with the thorax and abdomen of various shades of red to yellow mixed with black.

The nymphs and adults prefer the tender or mature pods but also affect the tender branches causing damage. When they feed they inject saliva that causes the formation of bubbles around the suction area which changes into necrotic lesions. If the attack is intense, the branches dry up and the leaves fall resulting in the condition known as “die-back”. They can cause withering of small pods, or the deformation of pods that reach maturity. The attack to large fruits in general does not seem to affect yield.

The population apparently fluctuates during periods of various years, and the local buds are affected by the climate and shade. Under good conditions of shade, there is less danger of harsh attacks.

Monalonion can be controlled with Malathion® and Metasystox®. Spray during periods of flushing and cover the total plantation. Good shade control will limit damage.

**4. Disease Control:** The chief diseases in the first year will probably be *Phytophthora* and Anthracnose (*Colletotricium gloeosporioides*).

**a. Phytophthora** in young cacao is characterized by the appearance on the leaf of dark brown or black irregular spots which grow and move through the veins. These soon turn brown and then black. There is a V-shaped dead spot formed and the large veins turn black. The disease may also start on the stem as black spots and grow up the stem into the leaves. *Phytophthora* will stunt or kill seedlings. Spray copper fungicides at ½

oz./gal. water plus ½ teaspoon of a sticker (i.e. Triton® x-7, Agral® 0.5%). Spraying may be needed at 2 to 3 week intervals during the wet months.

**b. Anthracnose** first appears as yellowish green patches on the leaf. These soon change to sunken spots with yellow borders as they get older. The spots will grow together and the leaf will turn brown. The disease can cause complete defoliation and can attack stems. This disease can kill small seedlings. Spraying every 2 to 3 weeks with Dithane® M-45 plus sticker will give control.

If both diseases are present you may combine copper and Dithane® M-45 and spray every 2 to 3 weeks.

**c. Pink disease:** This disease (*Corticium salmonicolor*) attacks a wide range of hosts. The fungus attacks cacao trees growing under very humid conditions. Twigs and small branches become covered with a thin white mycelium which turns pink and on which the spores are formed. The branches are defoliated and killed, but it is rare for the damage to extend beyond the loss of a few branches.

Attacks are dealt with by removing the affected branches well back from the point of apparent external damage. Incidence or infection may be reduced by improving the drainage in the plantation and adjusting the canopy of the cacao and shade trees to admit more light. Bordeaux mixture, applied preferably during the dry season, will usually control the disease. Copper sprays are also used as for *Phytophthora* (a) above.

**d. Thread Blights:** Several species of fungi cause thread blight, a disease which affects many plants in the tropics. In the West Indies, Brazil, New Guinea, New Hebrides, and Belize, *Corticium* species cause thread blights.

In attacks by these fungi, the creamy-white mycelium can be clearly seen as it runs along the twigs and sends out branches to the leaves, over the backs of which it spreads in numerous fine threads. The leaves are killed, turn a dark brown color, and remain suspended from the twigs by a thread of mycelium. The damage does not normally extend beyond the killing of leaves and small branches.

The incidence of the disease is worst in damp places in the wet season, and it normally spreads by contact. It is controlled by removing the infected parts and by copper sprays. Where it occurs frequently, the humidity should be reduced by decreasing the shade or pruning the trees.

**5. Pruning and Thinning:** For seedlings, the first year pruning will be limited to chupons. This should be done at monthly intervals and can be done with a sharp knife, or the chupons can be rubbed off with the hand. If double stems are forming one should be eliminated. This is all that should be done until the jorquette forms around the 10th to the 15th month. The jorquette

should form at 4 to 6 feet. If it forms too low, a chupon should be allowed to grow up and

produce a jorquette at the proper height. The low jorquette is then eliminated.

**Budded seedlings - a special training method:**

After 2 flushes and an average height of 80 cm (2¼ ft.), propping can be done. Use stakes long enough so the height of the prop will be 150 cm (5 ft.) above the ground. Tie up the clonal shoot to the stake so it will grow straight. All buds that begin to grow below 90 cm (3 ft.) should be pruned at 10-day intervals. This is done so no low-hanging branches are allowed to develop. In this way, vertical growth is encouraged. When the plant reaches 4¼ ft. the cacao seedling is topped by pinching the top bud. The buds above 90 cm (3 ft.) will start growing and will be used to form a false jorquette.