

NURSERY

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SAFODA
Sabah Forestry Development
Authority



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Agency

**Sabah Re-Afforestation Technical Development
And Training Project**

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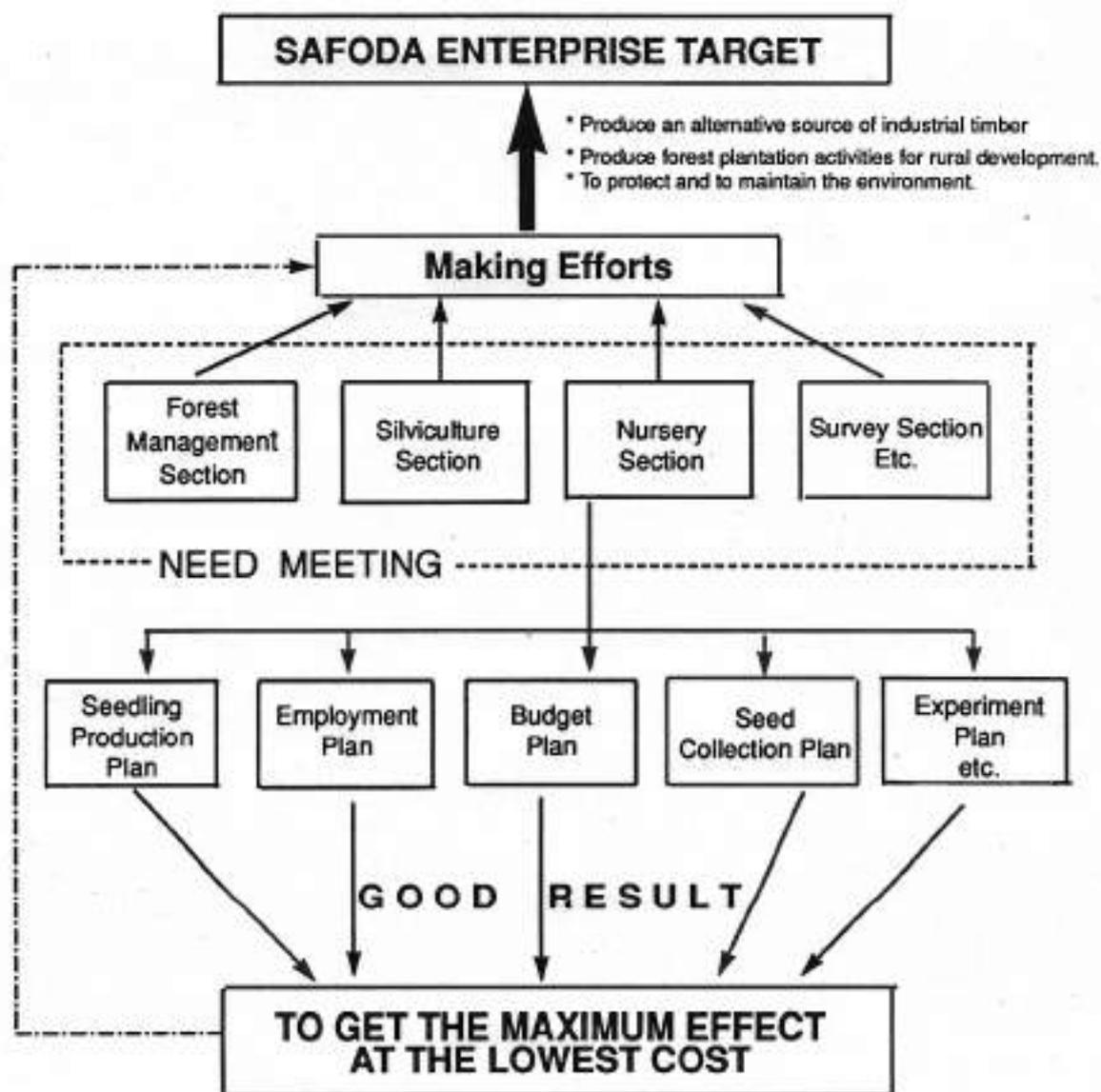
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1. NURSERY MANAGEMENT AND SUPERVISION

1 - 1 NURSERY MANAGEMENT

We are engaged in the business enterprise named SAFODA. We have certain future objectives concerning how SAFODA should be run as a business enterprise. Seedling production, which is carried out in order to achieve these objectives, must employ methods that achieve maximum results at minimum cost. One good method of achieving maximum results is to draw up plans -- plans for annual seedling production, employment plans and budget estimates. The intellectual (mental) labour expended drawing up such plans may be considered a management activity. SAFODA personnel with the approximate rank of "B" Course trainees must perform this management activity, always keeping SAFODA's future objectives in focus.

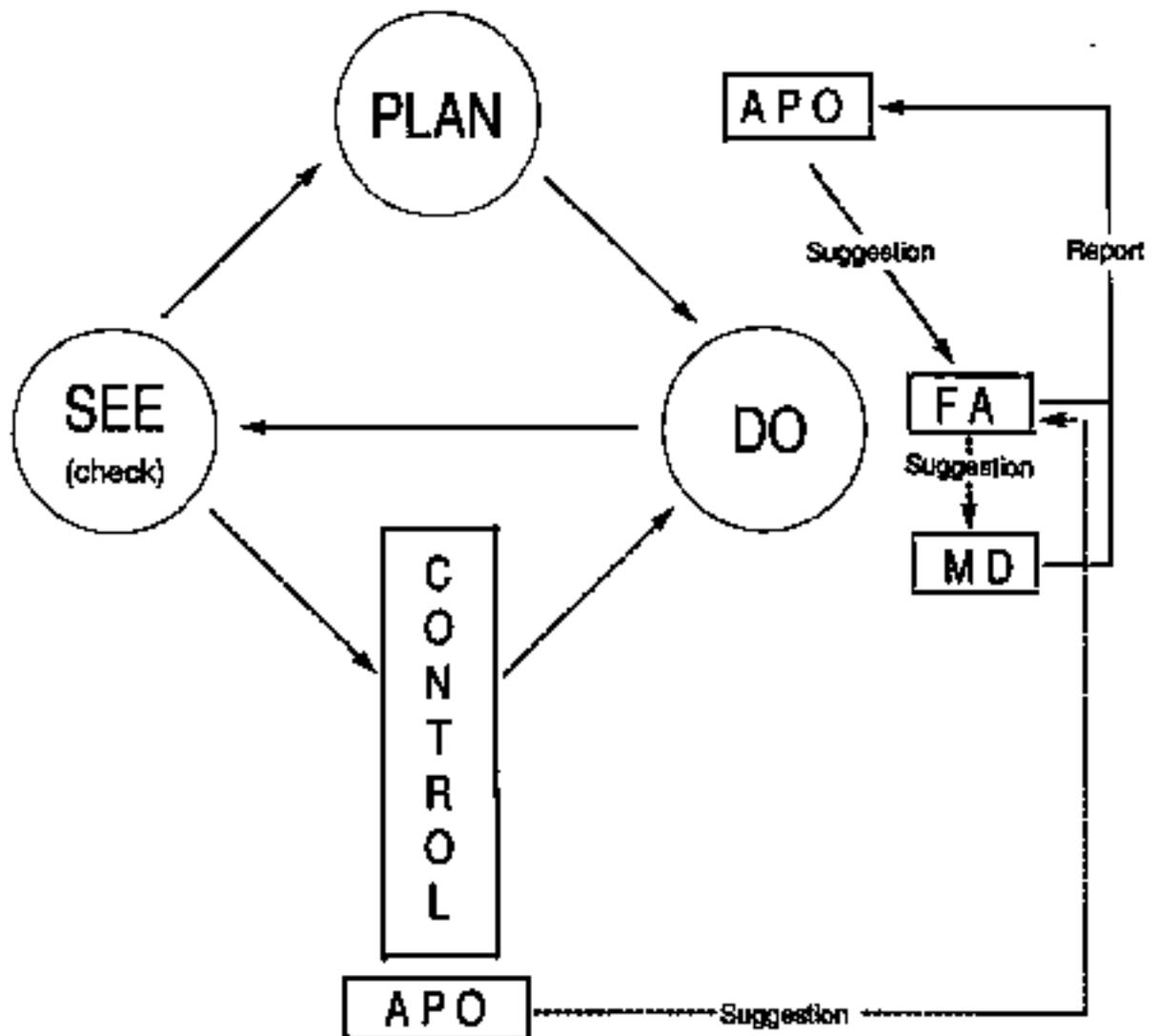
Figure 1. Flowchart of SAFODA target and nursery plan



1.2 NURSERY SUPERVISION

First, we make various plans. Next, we turn these plans into reality. When executing plans, it is necessary to check that plan details are being carried out in the correct way, that no unwarranted or ineffective procedures are being used, and that there are no problems developing. We call this checking procedure "nursery supervision".

Figure 2. Planning and Checking



1-2-1 ESSENTIAL SUPERVISORY ITEMS

(a) Seedling (product) supervision

In order to produce seedlings, either we import seed from overseas at high cost, or we make a big investment in manpower and gather seeds. We also import expensive machinery and employ many workers. In other words, seedling production incurs high costs.

We cannot afford to simply discard or destroy such seedlings. It is essential that we watch over and care for each and every seedling, every day, with the greatest care. Various things must be considered. For example, check that :

- seedlings have been watered sufficiently
- there are no signs of disease
- there is no insect damage
- there is enough fertilizer

Items like these can be checked by the field assistants or group leader, but, when necessary, checks must be made by officers in person.

One way of ensuring that checks are carried out properly and that problems are pinpointed at an early stage is to draw up a check sheet as shown below.

Figure 3. Seedling Cost

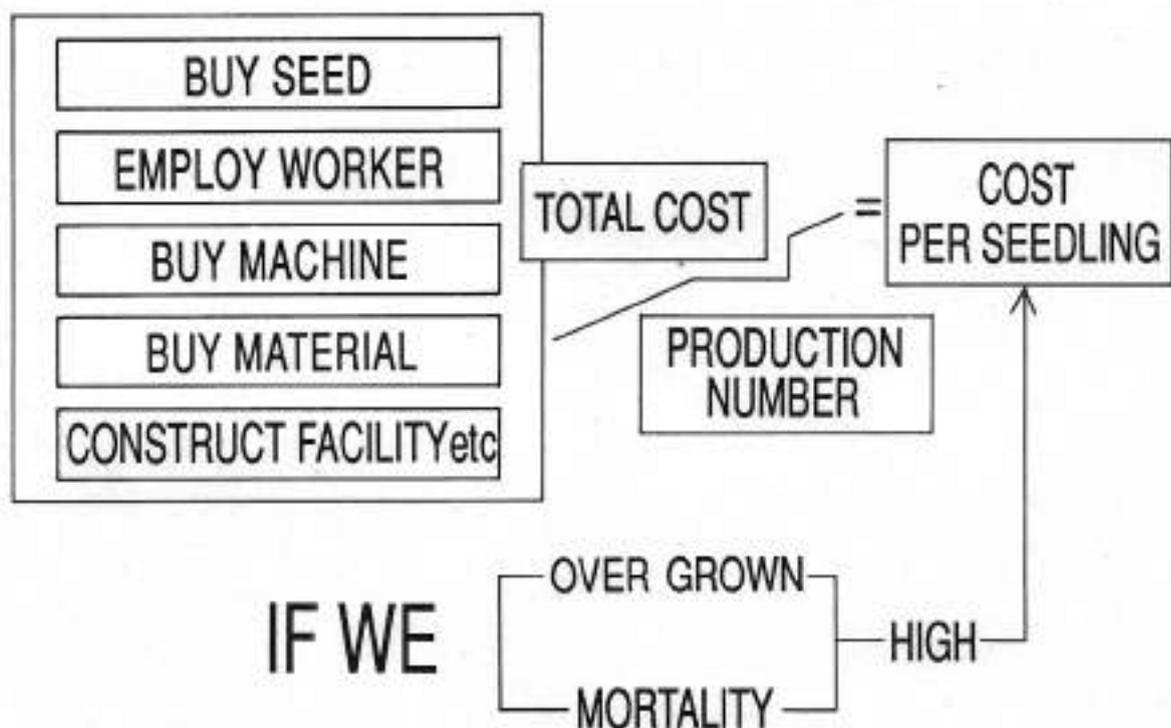


Figure 4. Inspection form

Day	Month	Year	Recorder	Inspector
Item	Condition		Remark	
Worker	Good or not			
Facility	Good or not			
Watering	Good or not			
Shading	Good or not			
Disease	Happen or not			
Insect	Happen or not			
Fertilizer	Enough or not			
Suggestion from Inspector				

(b) Worker supervision

Women make satisfactory nursery workers. This is because nursery work includes a lot of comparatively light tasks and many fine, delicate tasks, for which women are better suited. However, as there are heavy jobs to be done from time to time, two or three male workers must be included in each group.

There are times when it is effective to divide the nursery workers into teams. For example, when arranging pots, work can be carried out more efficiently if workers are organized so that some transport pots from the potting house, and another group hands the pots to a further group who place them in rows.

At such times, one thing that we must be particularly careful about is to make sure that there are not too many workers assigned to a task. For example, the following situation can sometimes be observed in our Kinarut nursery, and is an example of what should not happen.

In the Kinarut nursery there are five women workers. There is a task that normally takes five workers two hours to complete. In order to complete this task in one hour, ten workers were assigned to it. As a result, it was completed in one and one half (1-1/2) hours. If you do some simple arithmetic, you will see that this is the same as five workers standing around idle for one hour.

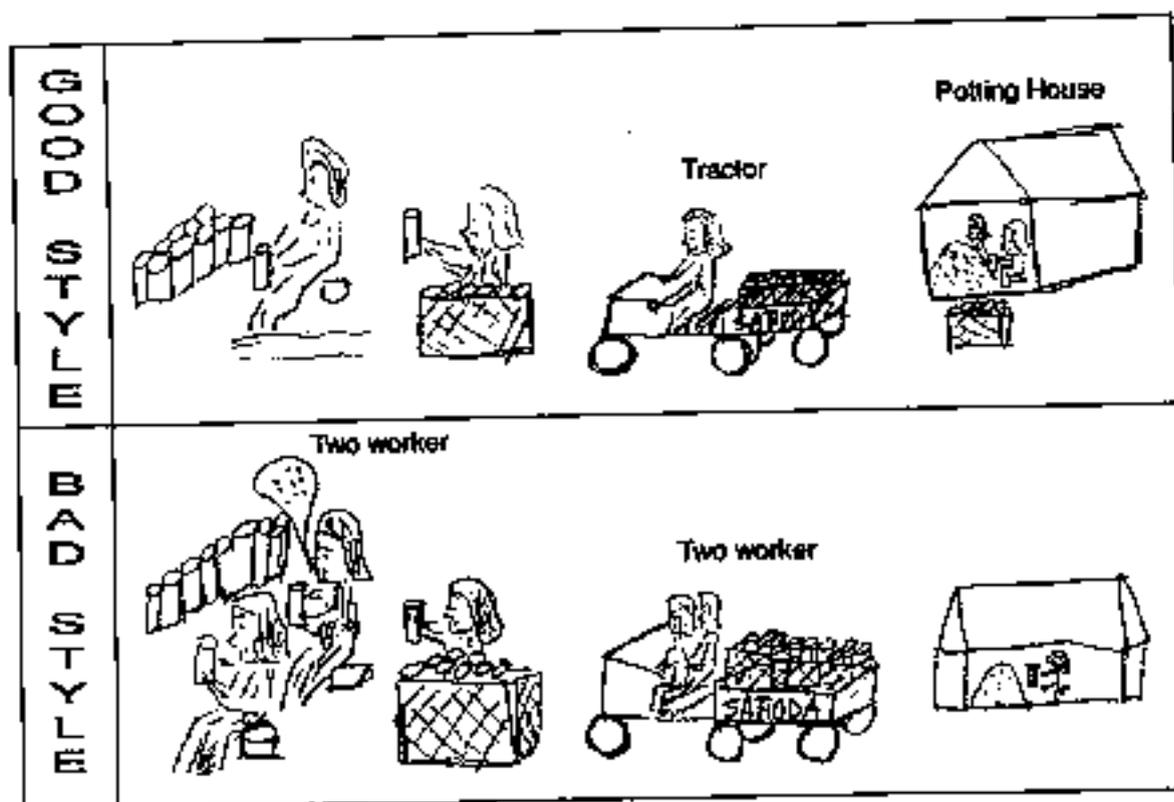
Assigning a surplus number of workers to a task quite unnecessarily only encourages gossiping, idle discussion, and idleness among workers, and so cannot be regarded as good worker supervision.

If an unsuitable number of workers have been assigned to a task, the situation

must be corrected with the help of the field assistant or group leader.

It must also be borne in mind that work efficiency in the nursery can be increased by noting the particular talents or skills of individual workers, and appointing these workers to tasks that make use of these talents.

Figure 5 Illustration on working condition



(c) Machinery supervision

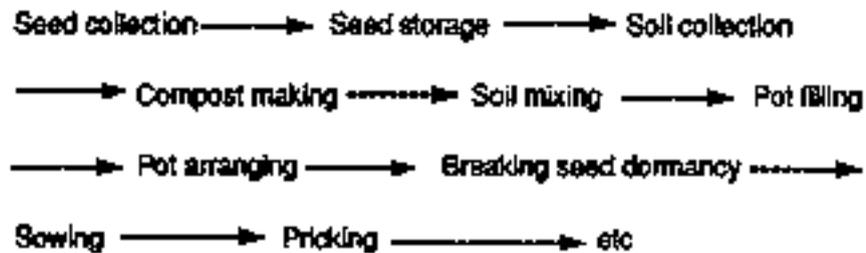
When machinery breaks down, a lot of money is needed to repair it. Also when machinery breaks down, work for that day is disrupted, causing severe reductions in operational efficiency. In other words, each machinery breakdown increases the cost of producing one nursery seedling.

This is why, when work finishes for the day, we must carefully and thoroughly clean all machinery and check if there are any parts that look weak or about to fail. All machinery should then be parked in the vehicle shed.

We must also carry out very rigorous checks about once a month. It is, of course, essential that machinery operators are taught correct operating procedures.

(d) Process supervision

The process of producing seedlings (seedling production operations) is similar to the kind of systematized operations that we see in industry.



All these separate processes do not take place in a sporadic fashion but are intimately related.

For example, let us imagine that we have just sown 100 grams of *Acacia mangium* seeds. This should produce about 9,000 to 11,000 young seedlings. However, if only about 2,000 pots have been prepared and arranged, about 7,000 to 9,000 seedlings will have to be discarded.

Process supervision in the case of seedling production is not a matter of supervizing a single process. The supervisor must be in command of the entire production process, planning work so as to co-ordinate the different, separate processes, at the same time ensuring that the work requirements of each separate process are satisfied.

(a) Cost supervision

Our ultimate aims when producing seedlings are to increase efficiency and reduce production costs as much as possible. We must always know how much it costs to produce one seedling, but as well as this we must also be able to calculate up to what figure SAFODA could invest funds in production without making a loss. At times when we are considering employing more workers or introducing more machinery, these standard cost calculations, done as part of cost supervision, take on great significance.

Table 1 Method of calculating Seedling Cost

A. Staff and Worker Cost			
1. staff a.	800 dollar/25 days x 18 days x 70%	=	403 dollar
b.	350 dollar/25 days x 18 days x 90%	=	227 dollar
c.	600 dollar/25 days x 1 day x 30%	=	7 dollar
2. Worker	12 dollar x 18 days x 10 person x 90%	=	1944 dollar

B. Material cost

1.	Fertilizer Used 1gr/per pot 18kg x 0.8 dollar	=	13 dollar
2.	Polyethylene bag 16,000 pcs/100pcs x 1	=	160 dollar
3.	Water 200 l x 13 days x 0.01 dollar	=	26 dollar
4.	Machinery		
a.	Tractor 12,000 dollar/5 years/365 days x 18 days x 30%	=	30 dollar
b.	Sieving 5,000 dollar/5 years/365 days x 5days x 50%	=	7 dollar
c.	Mixing 7,000 dollar/5 years/365 days x 5 days x 50%	=	10 dollar
d.	Others (shading net, Watering equipment, wood etc) (a + b + c) x 10%	=	5 dollar

C. Seeds collection and extraction cost

1.	Staff 800 dollar/25 days x 3 days x 100%	=	96 dollar
2.	Worker 12 dollar x 5 days x 2 person x 100%	=	120 dollar

COST PER SEEDLING

3,048 dollar	9,600 seedling	=	0.32 dollar
	Pricking number 16,000 seedling		
	Survival rate 60%		

(I) Safety supervision

However much we may aim to increase efficiency and reduce costs, it is not desirable that this brings about an increased incidence of accidents causing worker injury or death.

It is therefore necessary that checks be made and supervision be carried out to ensure that workers are not performing dangerous manoeuvres. Of course, when a physical danger, for example, failed brakes on a tractor, is discovered, this danger must be removed immediately before any accident can occur.

1-3 PRODUCTION PLANNING AND PLAN CONFIRMATION

1-3-1 THE MEANING AND IMPORTANCE OF PRODUCTION PLANNING

In production planning, we draw up a production plan which we then execute. The plan stipulates the number of seedling trees, production time, quality, etc., based on a comprehensive study of levels of demand from each section, our production capability and technological capability, and our budget.

As we said in Section 1-1, when we make this plan, we are constructing the very foundations of our business enterprise. If these foundations are constructed in a shabby or random fashion, many problems will emerge in our nursery work, in the first instance, and in the afforestation and forestry sections as well. In fact, the negative effect of bad planning will be felt even in SAFODA's business activities, where serious obstacles will develop.

It is essential that we thoroughly understand how important it is to make a production plan.

1-3-2 CONFIRMING A PRODUCTION PLAN

Having drawn up our production plan based on the factors described in Section 1-3-1, it is not simply a matter of executing work operations according to the plan. First, from time to time we must check whether or not we have planned correctly, making corrections where necessary. Next, we must pinpoint problem areas and make sure that they are reflected in the next production plan.

1-3-3 CONFIRMING PRODUCTION PLANS - SOME GENERAL PRECAUTIONS

(a) Ensure all sections are properly contacted

Having sufficient meetings with all sections prevents having to make changes to the production plan just before production begins. Regular contact with all sections also prevents the occurrence of blunders such as producing seedlings only to find that they will not be used.

(b) Keep expenses low

If we operate our workplace as a business enterprise, the pursuance of profit comes naturally. When dealing with requests from all sections, always take care to keep costs down, even where requests are related to seedling production.

It is essential that we check whether or not such care is being taken.

(c) Always keep the planting out time in mind

It is essential that we plan production so as to be able to meet the planting out date issued by each section, producing seedlings to be in the very best condition on this date. For this purpose, the following table is a useful reference.

Table 2. Seedling production plan.

Seedling Production and Planting Plan in 1991

SPECIES	SECTION	REQUESTED NUMBER	PRODUCE NUMBER	MONTHS												REMARKS					
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC						
				E	M	L	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L
Acacia Mangium	S	42,500	46,750																		
- do -	Fm	4,000	4,400																		
Albizia falcataria	S	2,220	2,440																		
Dipterocarpus SpP	S	2,080	2,290																		
Dillenia suffruticosa	Fm	8,000	8,800																		
Eucalyptus deglupta	S	4,800	5,280																		
Eucalyptus urophylla	S	4,800	5,280																		
Gmelina arborea	S	3,300	3,630																		
Hybrid (A.m x A.g)	S	200	220																		
Pterocarpus indicus	S	2,220	2,440																		
Swietenia macrophylla	S	2,220	2,440																		
- do -	Fm	1,000	1,100																		
Theobroma cacao	Fm	1,000	1,100																		

EXPLANATORY NOTES

- S : SILVICULTURE
- Fm : FOREST MANAGEMENT
- E : The first ten days of a month
- M : The middle
- L : The last ten days of a month

- Collect seeds : oooooo
- Collect action : xxxxxxx
- Sowing : -----
- Pricking : _____

- Cutting : // // // //
- Control in Nursery : []
- Planting : []

1-4 INCREASING OPERATIONAL EFFICIENCY

1-4-1 PRINCIPLES OF INCREASED OPERATIONAL EFFICIENCY

In what ways can we increase the efficiency of our operation? This is something we should always be thinking about. If we pass each day with careless lack of concern, we surely cannot hope to substantially increase our operational efficiency.

When supervizing operations, it is extremely advantageous to know the following basic principles of increased efficiency.

(a) The principle of conversion

This is the principle of planning to increase efficiency by changing a part of present operations from a man-powered or animal-powered operation to a machine-powered operation.

In other words, we examine whether machinery can be introduced into the present operational system.

(b) The principle of supplementation

This is the principle of examining whether or not some part of the present operational method can be supplemented. For example, by supplementing workers with a number of extra workers, efficiency is increased several times over.

(c) The principle of allotment

This is the principle of division of labor, so that any one worker does not perform the entire work operation. —By dividing the tasks between workers, each worker increases his level of skill for his particular task. At the same time, the work of each worker is simplified, and therefore his work speed increases.

(d) The principle of interconnection

This is the principle of conducting work in an interconnected fashion. Here is a negative example.

If, when producing seedlings, we prepared 10,000 pots, but they cannot be pricked because there is no seed for them, these pots that we have so laboriously prepared will be wasted. At the same time as producing pots, it is essential to check whether or not seed is available.

(e) The principle of enthusiasm

This is the principle of all personnel, including workers, possessing a genuine interest in, and enthusiasm for, the business of producing seedlings.

1-4-2 DEVELOPING AN ABILITY TO INCREASE OPERATIONAL EFFICIENCY

(a) Fostering creativity

Group leaders and workers of similar rank should think about their own particular work tasks, and try to devise the easiest and most efficient way of performing them. They should then take their ideas, and try applying them to the entire operation. Once a worker finds that his or her idea has been adopted, he or she will be keen to think up more useful ideas in the future.

(b) Posting progress reports on work volume targets

If we know what our work target is for the month or the day, we feel pleased and enthusiastic when we manage to reach it. In the same way, if we show workers what the work volume target is for the year, or the month, or the day, we can increase their desire to work. It is essential to keep workers informed about their work progress, regularly telling them how much further they have to go to fulfill work volume targets.

(c) Explaining the aims of each operation

We must always explain to workers the aims of an operation - what the product is to be, and when, where, in what way, and in what quantity it will be used. If workers are told these details, they will work speedily to meet targets.

(d) Maintaining order and cleanliness in the workplace

Nursery work involves the use of various containers and also chemicals. Maintaining strict order and tidiness enables work to be carried out speedily. An orderly workplace also helps prevent errors and accidents caused by incorrect handling of chemicals. A clean and tidy workplace also boosts worker morale, for coming to work each day to a clean and orderly work environment has an uplifting effect.

2. NURSERY ESTABLISHMENT

Natural forests are becoming on the decrease. Recently, we can not easily find it. If we think to observe tropical jungle, it is becoming a difficult matter.

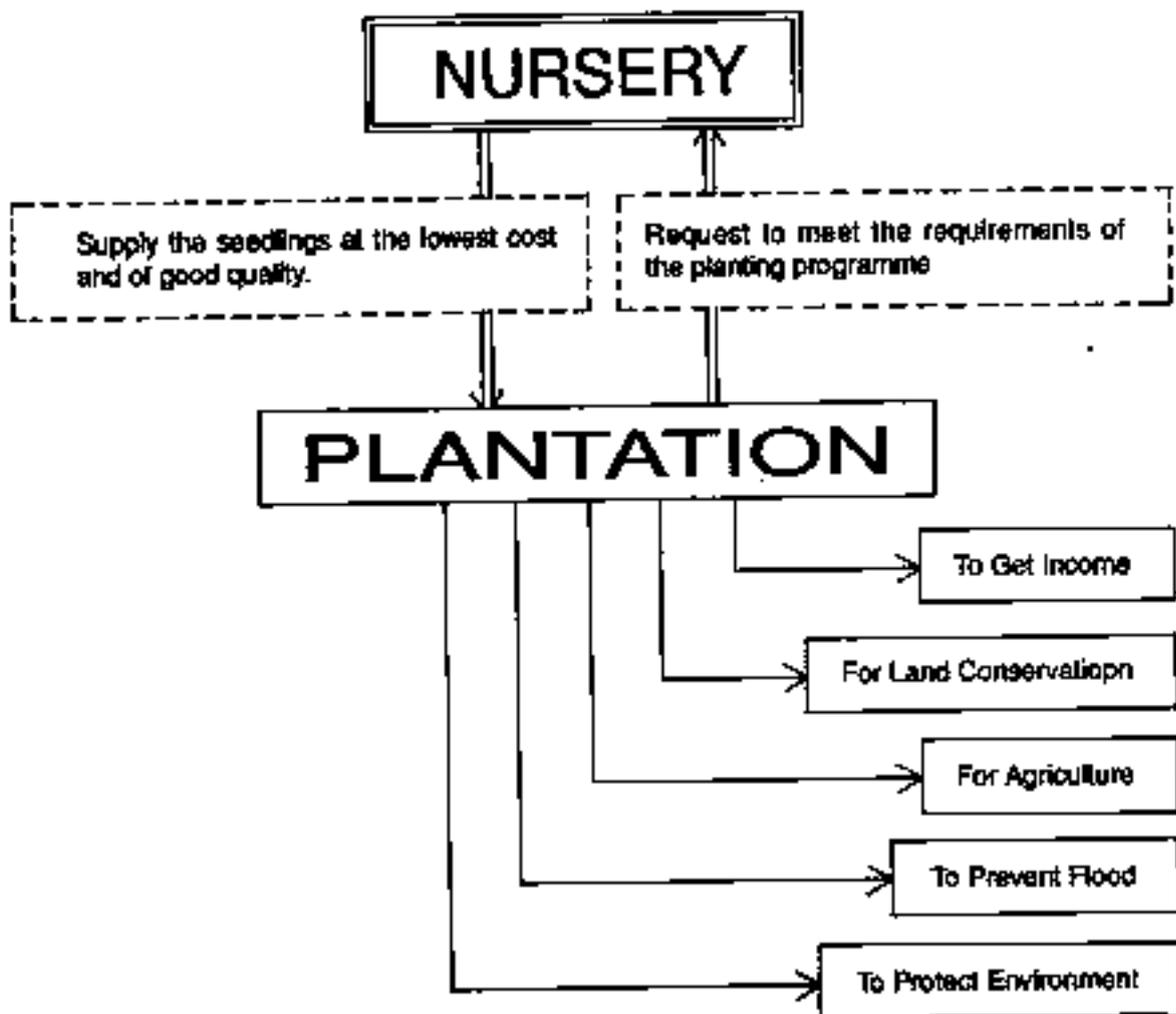
Even these jungles are being cut down so extensively that many tree species are now extinct.

To improve this trend, intensive afforestation and reforestation is being conducted by many plantations.

It is necessary for a plantation to establish a forest nursery, because we must steady and continuous supply of a sufficient number of seedling of specified species to meet the requirements of the planting programme.

For this reason, it is the primary objective of the nursery to produce, at the lowest possible cost, good quality, healthy, and vigorous plants that will be at the right age and size at the planting time.

Figure 8 Necessity of Nursery

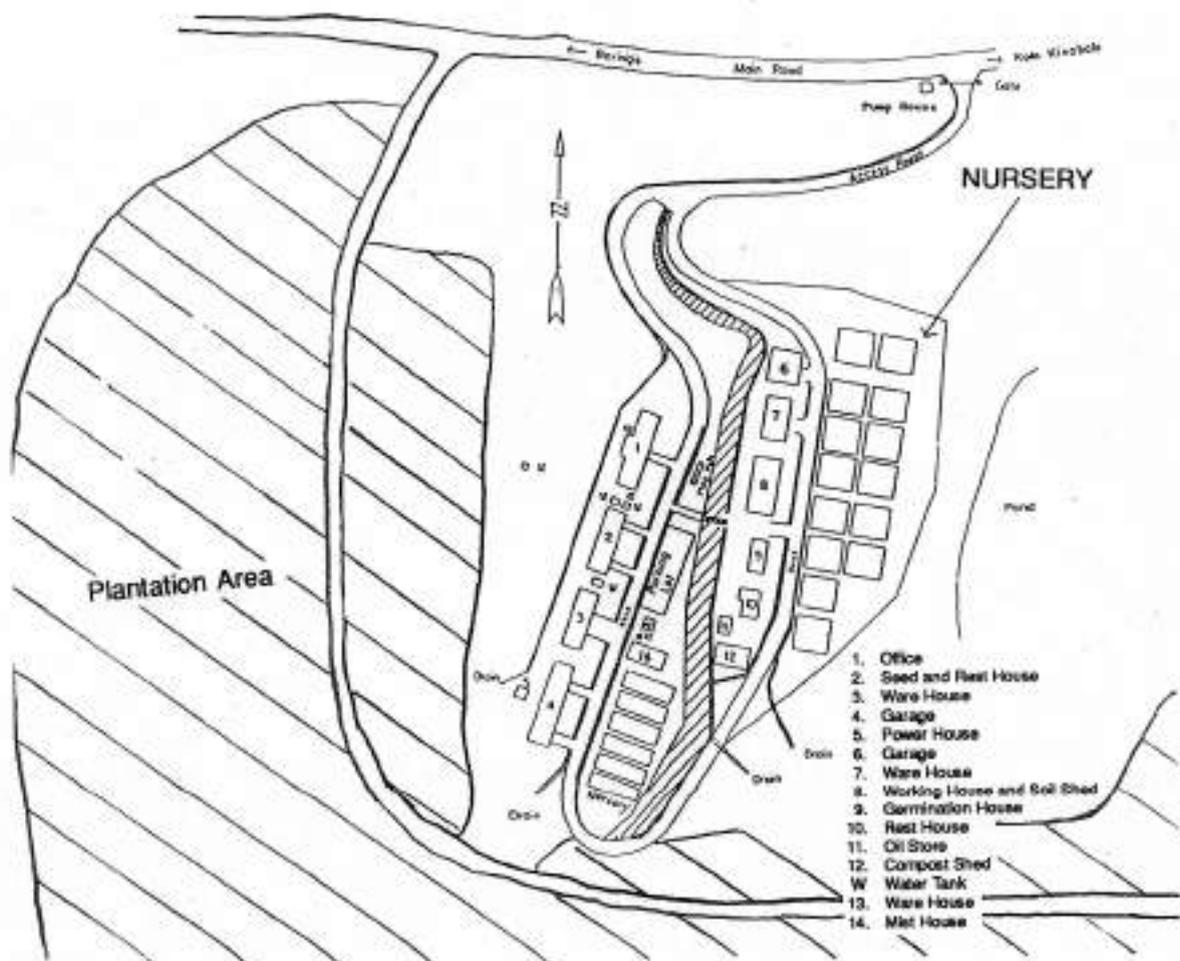


2.1 Choice of Site

The following basis should be considered in choosing a nursery site:-

- (1) Proximity to the planting area so that the seedlings suffer minimally from wind burn, overheating, loss of soil, and bruising caused by vibration while in transit.
- (2) Easy access to water supply, e.g. a stream, pond, or if possible, a piped water system.
- (3) Location in an area where there is sufficient workable soil for potting mixture.
- (4) Suitable topography: Relatively flat with sufficient space to accommodate all nursery structures.
- (5) Proximity to a village providing potential source of skilled workers.
- (6) Proximity or with easy access to a road.

Figure 7 Layout of Kinarut nursery



2.2 Size

The size of the nursery is considered and determined the following:-

- (1) **Methods of raising seedlings:** whether the nursery has to produce potted seedlings, bareroot seedlings or others. If pots, we must consider the space to be occupied.

With bareroot and other methods, we must consider crop rotations and space of uncultivated areas for transfer.

- (2) **Size of polybag to be used.**
- (3) **Maximum number of plants required annually.** This depends on the plantation's production target.
- (4) **The length of time that the seedlings have to stay in the nursery is varies from species to species.**
- (5) **Area allotted for the different facilities.** This includes space for roads affording easy access to the nursery and for pathways around the sowing bed area.

2.3 Design and Layout

Specifications for the design and layout of the nursery depend on the topographical characteristics of the location, nursery size, and the particular requirements of the management.

Design here means an overview of the nursery, similar to an aerial photograph.

Layout means a plan of the entire nursery's perimeter.

When planning design and layout, management have to consider the following factors:-

- (1) A nursery should be compact and approximately square to minimize length of boundary, especially if some animals come to nursery, a protective fencing has to be installed.
- (2) The potting bed unit must be well located, and beds should be aligned east-west. to provide even shading throughout the day.
- (3) Pathways between seedling beds must be allowed for. About one meter in width is sufficient. Similarly, roads throughout the nursery should give good access.
- (4) All land spaces must be occupied and function to prevent weed growth, although some appropriation has to be made for further development and expansion.

2.4 Water Supply

In seedling production, the water is most desirable that it is supplied plentiful and readily available water in the nursery.

The nursery should be located near either a permanent stream or the place where water can be piped all year round.

If the supply of water during the dry season is not done and the tap water is expensive, the water storage tank should be built to the place where the stream water can be impounded or rainfalls water can be collected and stocked.

It is better to set up a water pipe system inside the nursery to reticulate water from taps.

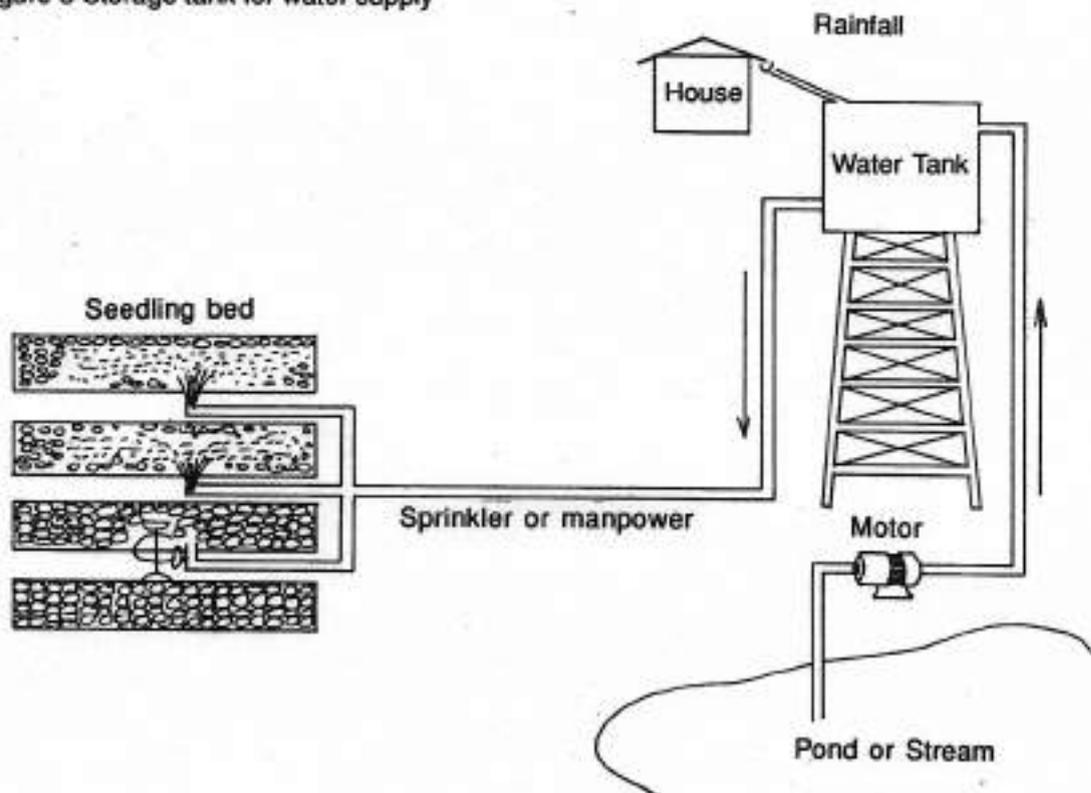
These should be well distributed so that it is possible for every part of the nursery to be reached by a 30 meter hose.

Watering with a hose is very much better than with a watering can, since it only needs less effort and it can be used to supply an adequate amount water to the seedling.

Sprinkler watering system are sufficient due to saving manpower but they tend to waste water.

Therefore they should be installed only in the nursery where it needs to supply much water.

Figure 8 Storage tank for water supply



2.5 Facilities

In any enterprise or association, the establishment of an office is a logical necessity.

The core of management is to operate and administer its functions. In short, the office is very important.

In the same sense, when planning the nursery layout and design, provision should be made for the different facilities that are needed to supervise nursery operation and activities.

Adequate facilities generally enhance operations and help achieve the ultimate objective of seedling propagation.

Additional details about our facilities are as follows:

- | | |
|-------------------|---|
| Office | - For general management which completed with rest room, training class, computer room, meeting room, seed room, etc. |
| Store | - For keeping equipments, fertilizers, tools, chemicals, etc. |
| Working house | - Accomodation for potting mixture, filling, branch cutting, seed extaction, for storing soil and sand, etc. |
| Seed house | - For seed storage, etc. |
| Germination house | - For seed cleaning, preparation of seed sowing for keeping box of sowing seed, etc. |
| Compost house | - For preparation and compost storage providing a continuous supply of humus. |
| Misting house | - For cutting |

2.6 Tools and equipment

Good work can not be accomplished without the necessary tools and equipment.

To propagate plants successfully, tools must be effective and efficient, and their use follow standardized procedures of orderliness and cleanliness.

When tools are lent out to workers, strict records must be kept and responsibility must be made clear so that tools will not be lost.

To avoid pilferage of equipment and tools, the posting of security guards is necessary.

The use of appropriate tools and materials can determine the success of propagation techniques and procedures.

After usage, it is mandatory that equipment and tools be cleaned and returned to their proper places, to make them readily available, and accessible to the next user.

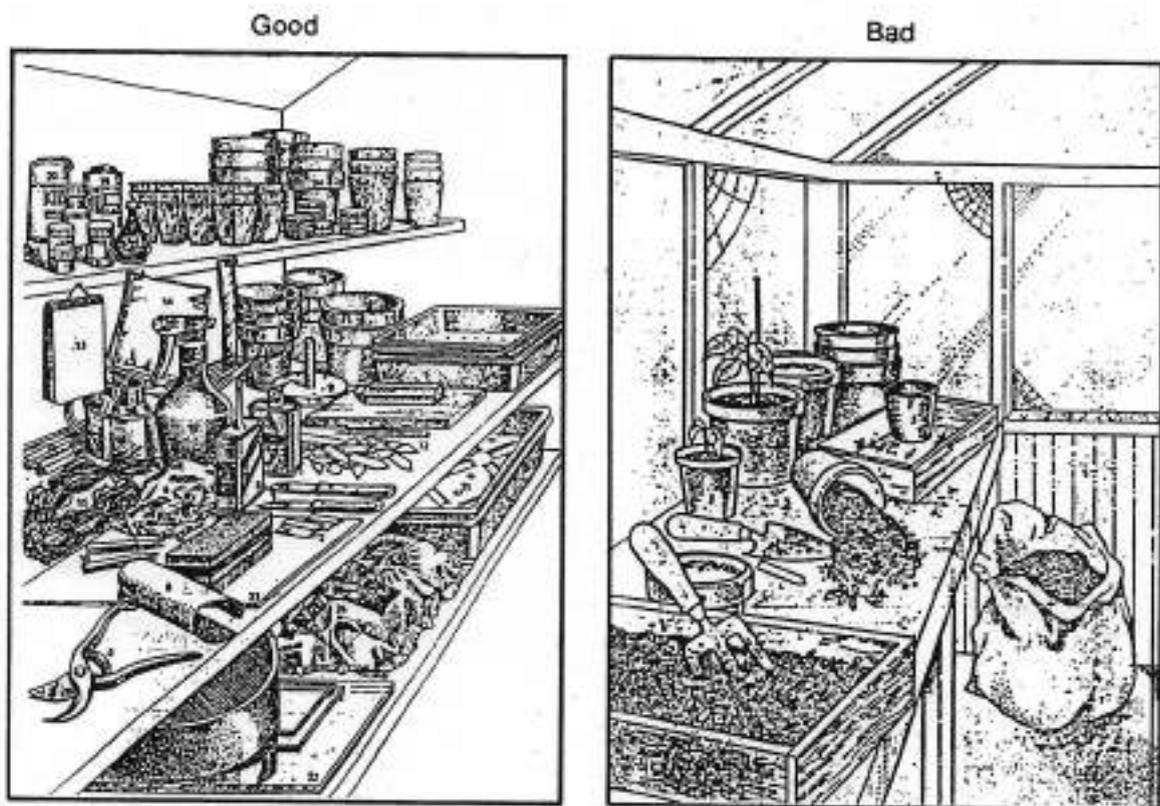
Our project possesses the following tools and equipment:-

cars, pick up,
tractor,
concrete mixer,
water pump,

sprayers,
wheel barrows,
weight scales,

rakes, shovels, scoops,
seed containers, sowing boxes,
recordbooks, labels, shades,
polythelene sheets and bags,
files, sharpening stones,
knives, scateurs, scissors,
saws, hammers, nails, wires,
sieves, water hoses, watering
cans, buckets, basins, hoes.

Figure 9 Arrangement of Tools and Equipment

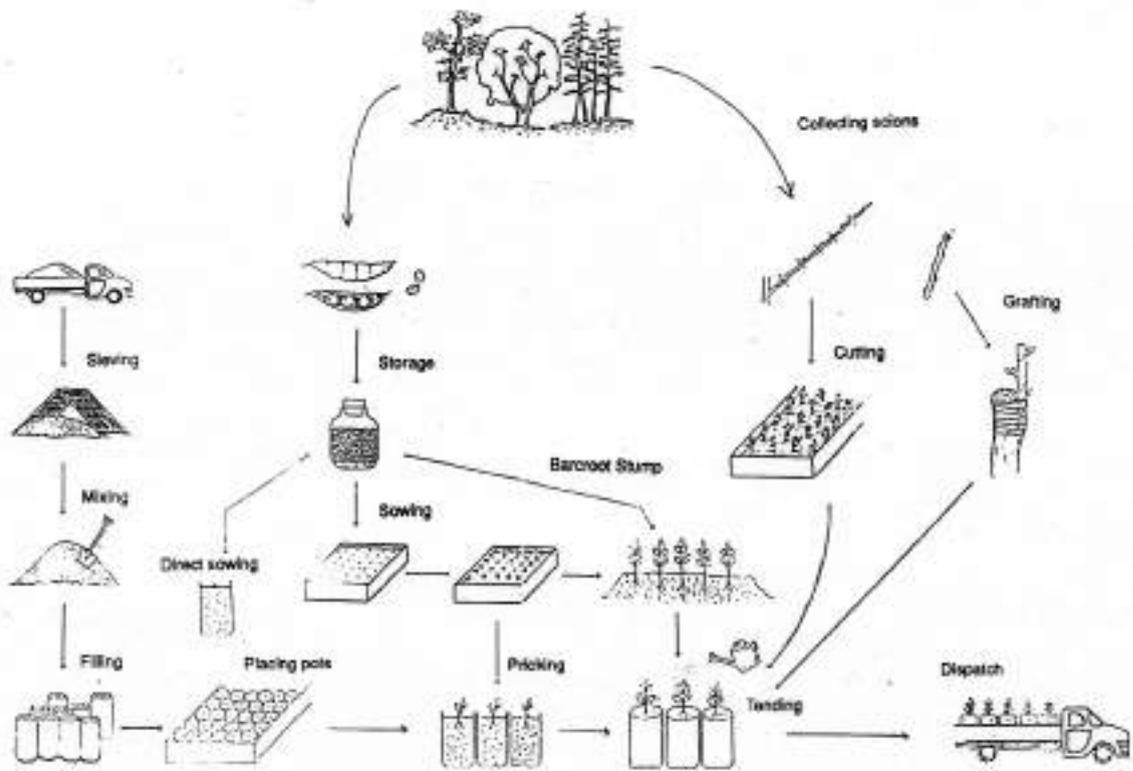


3. SEEDLING PRODUCTION

This is an important stage in the nursery programme. Seedling production is not limited to the production of young plants from seeds, but explores further possible methods of reproduction, such as vegetative propagation.

The requirements and methods involved in producing seedling from seeds are discussed below.

Flowchart of seedling production



3.1 Time of Sowing.

In our practice, sowing is the methodical scattering or planting of seeds on moist soil.

Seeds are scattered uniformly and not too thick over the surface of the moist soil and then covered with a thin layer of soil, usually with the help of a small sieve. After a few days, the seeds will germinate, emerging as new plants.

For *Eucalyptus* spp. seeds, we must do soil heating before sowing. This seed is very delicate to disease attack.

Figure 10 Procedure of sowing

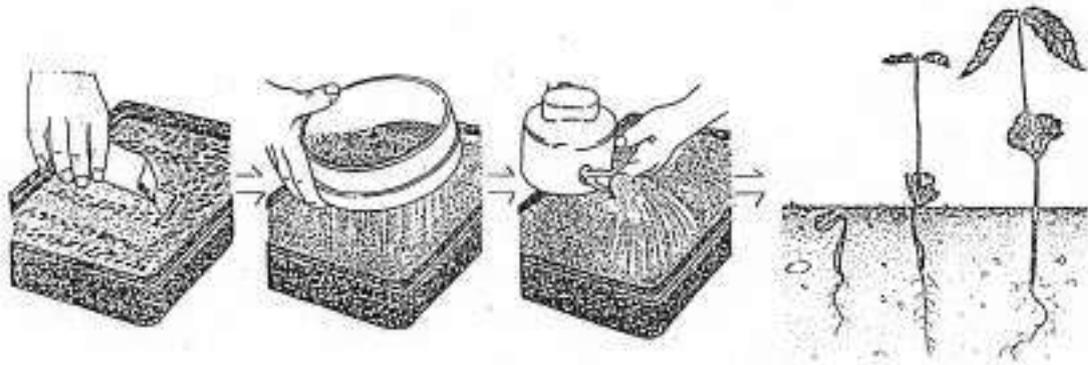
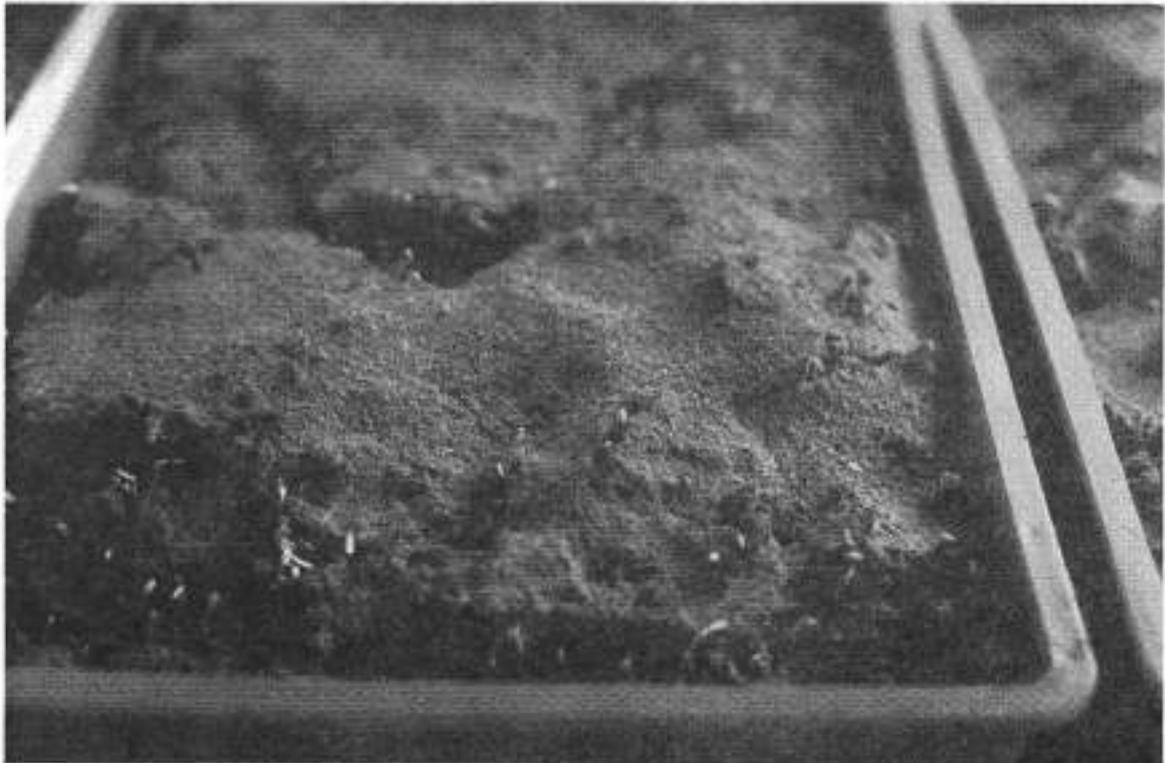


Figure 11 Picture shows bad covering



Time of sowing is important since seedling must attain the correct size by the start of the planting time.

If this take five months from the time of germination, then seeds should be sown five months before the time for planting.

The nursery section should inform another section for the planting schedule of each species.

They know how much time each species require to reach the necessary size for planting out.

Table 3 Guide lines on seedlings production

Species	Growing term	Height	Diameter	Remarks
	month	cm	mm	
<i>Acacia auriculiformis</i>	3 - 4	40 - 50	4 - 5	
<i>Acacia mangium</i>	3	40 - 60	5 - 6	
<i>Albizia falcataria</i>	3 - 4	50 - 70	8 - 10	
<i>Araucaria cunninghamii</i>	8 - 15	3 - 40	4 - 6	
<i>Bauhinia purpurca</i>	4 - 6	40 - 60	6 - 8	
<i>Casuarina equisetifolia</i>	4 - 5	50 - 60	4 - 5	
<i>Eucalyptus deglupta</i>	3 - 4	40 - 60	5 - 6	
<i>Gmelina arborea</i>	3	40 - 50	8 - 10	
<i>Gmelina arborea</i>	4	40 - 50	10 - 15	Bareroot
<i>Leucaena leucocephala</i>	3 - 4	50 - 70	6 - 8	
<i>Paulownia fortunei</i>	6 - 10	60 - 80	10 - 15	
<i>Pinus caribaea</i>	8 - 10	30 - 50	4 - 6	
<i>Pinus occarpa</i>	8 - 10	30 - 50	4 - 6	
<i>Pterocarpus indicus</i>	4 - 5	40 - 50	5 - 6	
<i>Pterocarpus indicus</i>	4 - 5	50 - 60	6 - 7	Bareroot
<i>Shorea leprosula</i>	6 - 8	40 - 50	6 - 8	
<i>Swietenia macrophylla</i>	4 - 5	30 - 40	7 - 8	
<i>Swietenia macrophylla</i>	4 - 5	30 - 40	8 - 10	Bareroot
<i>Tectona grandis</i>	5 - 6	40 - 50	12 - 15	Bareroot

3.2 Germination test

Germination is the initiation of new genetic program in the life of a tree.

In germination, the embryonic axis is returned to the state of growth which has temporarily suspended during dormancy or during storage.

Before sowing, there is a need to determine the quality of the seeds in order to calculate the quantity of seeds to be sown.

As for treatment, the following tests can be carried out.

There is germination test in a sowing box, a petri dish, or on an unglazed plate.

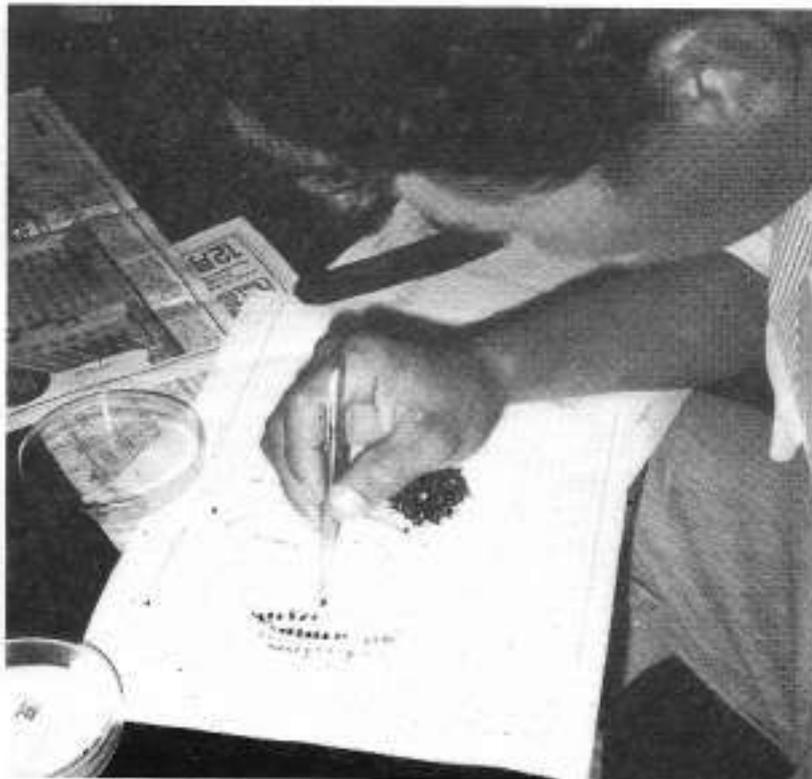
Soil, sand, sawdust, paper, or just moist air are generally the media or the substrata used to germinate seeds in sowing boxes or petri dishes.

Most popularly used are blotting paper or paper towels, as these give uniform results for any species due to the absence in paper of minerals which could influence the rate of germination. The germination rate in other media may be biased by mineral content.

If a sowing box is used, it is filled with either soil or sawdust. If a petri dish is used blotting paper is placed inside and wetted. In both cases, the seeds are then counted and arranged in rows on the medium.

If a unglazed plate is used, seeds are first arranged, then the plate is put into a basin of water, which seeps slowly through the unglazed plate. The petri dish or unglazed plate is sometimes placed in a germination test machine with controlled temperature.

Figure 12 Illustration on seed counting



Generally, the conditions necessary for germination are the following:-

- (a) Viable seed - selected from stock with good genetic qualities and characteristics.
- (b) Water - dry seeds respire slowly but if they absorb water the rate of respiration increase, bringing about germination.
- (c) Suitable temperature - most plants have an optimum temperature at which germination and seedling growth take place.
- (d) Light in some species - either sunlight or artificial light.

Results of germination by all methods are recorded in a log book in order to calculate the quantity of seeds to be sown.

Germination capacity is expressed as a percentage and is calculated by taking the number of seeds that actually germinated, dividing it by the total number of seeds tested, and then multiplying the result by one hundred. In a sample of 400 seeds, if 260 germinated, we have a 65% germinating capacity.

Quantity of seed

Amount of seeds to be sown can be calculated as follows:

$$W = \frac{S}{N \times G \times SR}$$

Where:

W = Weight of seed to be sown (grams or kilograms)

S = Number of young seedlings to be pricked

N = Number of seeds per gram or kilogram

G = Germination rate (as decimal)

SR = Survival rate or utilization rate (as decimal)

Example:

Suppose we have to prick 100,000 pots of *Acacia mangium*

(S), Germination rate is 70% (G), 80% of seedlings are expected to survive (SR), and there are 105,000 *Acacia mangium* seeds per kilogram (N).

$$W = \frac{100,000}{105,000 \times 0.7 \times 0.8} = 1.701 \text{ kilogram}$$

The amount of seeds to be sown is 1.7 kilogram

3.3 Treatment

The purpose of seeds treatment before sowing is to hasten and increase the germination rate or to achieve uniform growth during germination.

We can think of four classification as follows:-

(a) Floating

It is always advisable to try to remove empty seeds before sowing. Placing the seed in a bowl of water and discarding the "floaters" is an effective way of removing empty seeds.

(b) Soaking

Before seeds can germinate, it is essential that they take up water. Soaking before sowing often results in a quicker and more uniform germination. The seed has to be partially dried again before sowing.

(c) Soaking in hot water

With the leguminosae, the time in the sowing box can be shortened and germination can be increased by soaking seeds in hot water.

An effective method is to bring the water to a boil. Put the seeds inside a cloth bag, then soak the bag in a boiling water for two minutes. After that time, remove the cloth bag from the boiling water for one night.

(d) Soaking and drying

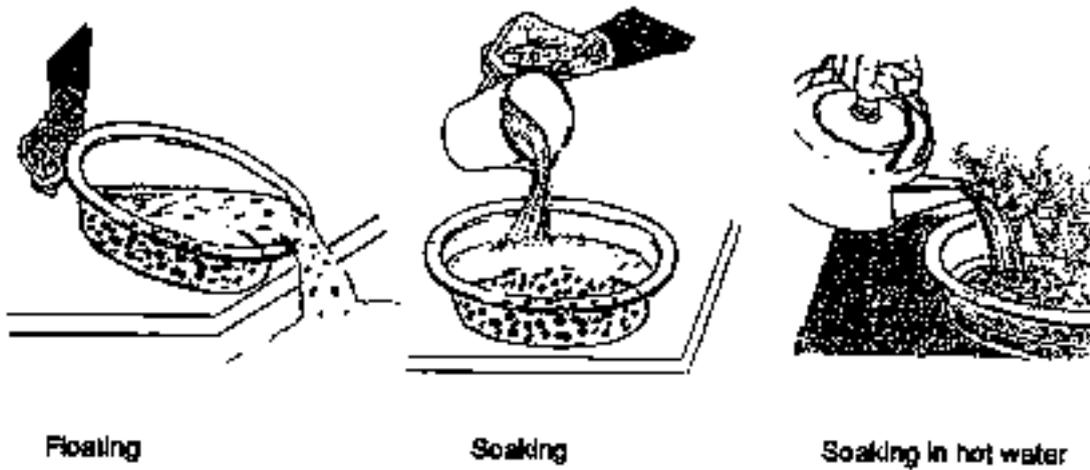
Some species have very hard seed coats, and these have to be broken down in some way before water can enter and start the germination process.

Teak is an example of such species. It is sometime recommended that the seed is alternately soaked and dried. This is preferable to soaking in running water.

Seed treatment for germination

Method	Species
Floating	<i>Pinus spp.</i>
Soaking in Water	<i>Gmelina arborea</i>
Soaking in hot water	<i>Acacia mangium</i> <i>Leucaena leucocephala</i>
Soaking and drying	<i>Tectona grandis</i>
No treatment	<i>Eucalyptus spp.</i> <i>Paulownia spp.</i>

Figure 13 Illustration on seed treatment



3.4 Sowing

Sowing is very important in seedling production process. Because the germination rate at here is affected to future seedling production, so we have to do a prudent treatment.

In our project, we have adopted three ways of sowing seeds.

(a) Sowing seeds in sowing boxes.

Plastic sowing boxes of measuring 50 cm x 35 cm in depth are more convenient to handle and are more durable.

River sand, heated soil, or sawdust are used to fill the boxes. The calculated number of seeds should be spread evenly in the box, then covered with sowing medium to 2 to 3 times the depth of seed diameters.

The seeds should be watered after sowing and the medium must be kept moist throughout the germination phase until pricking time is due.

Fine and light seed like *Eucalyptus* spp. or *Paulownia* are commonly sown in these boxes. For *Acacia mangium*, this method is more suitable than direct sowing.

The advantage of this method is that each pot will have only one seedling but it is time consuming as it requires more manpower.

(b) Direct sowing to pots

Medium-sized seeds like *Leucaena Leucocephala*, *Pinus* spp. or *Gmelina arborea* can be sown directly to pots. The main with this method is the risk either that no seedling emerges or several do if more than one seed is sown.

Nevertheless, where 2 or more seedlings do occur in a pot, the surplus can always be pricked out into empty or any other new pots.

The number of seeds to be sown in each pot depends on the germination rate of the seeds. The following guide is applied.

(c) Promoting seeds in sawdust

Most of *Dipterocarpaceae* seeds such as *Shorea* spp., *Hopea* spp., can not be stored even for only a few days after collection as they immediately lose their viability.

These seeds are immediately processed in the germination house. It is advisable that they are placed in a big basin with wet sawdust inside the germination house. One or two weeks later, young seedlings about 5 cm to 10 cm in height can be transplanted to pots under thick shade.

Figure 14 - 1 Illustration on sowing in containers

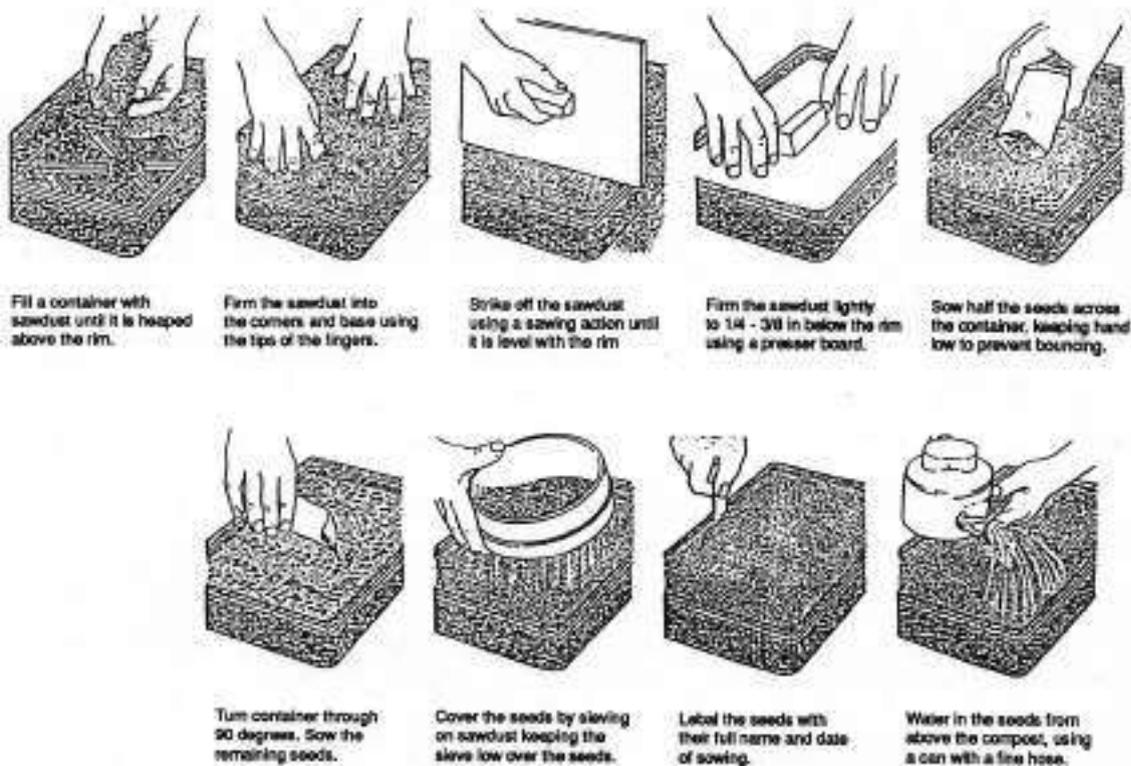


Figure 14 - 2 Illustration on sowing in a seedbed

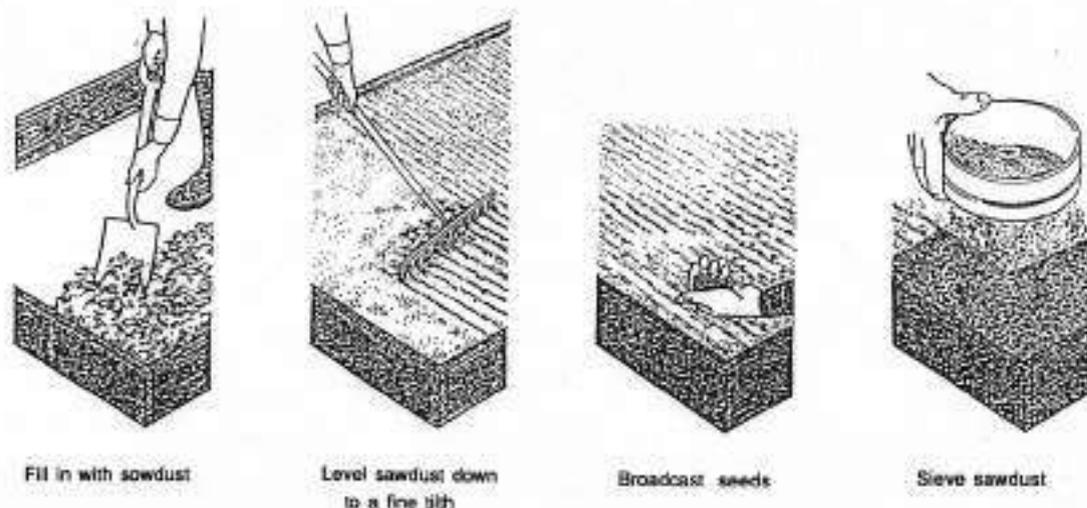


Table 4 Number of seeds to be sown for direct sowing

Germination rate	Seeds to be sown per pot
81% - 100%	1
61% - 80%	2
40% - 60%	3

Figure 14 - 3 Illustration on direct sowing



3.5 Potting

Potting is the process of preparing pots using some kind of container and medium that will support the growth of young plants.

In a nursery, potting begins at the time seeds are germinated to ensure immense production of young sprouts.

Before starting to propagate any species, nursery men should have already decided what containers and medium are to be used. The strategy is to prepare the things needed in advance to insure the efficiency in propagation.

Normally, tree seedlings would be produced bare rooted as this economizes the cost of propagation and the cost of handling till planting out. However, in tropical areas with hot and dry conditions, potted seedlings have a better survival rate.

For this reason we produce mainly potted seedlings in our project.

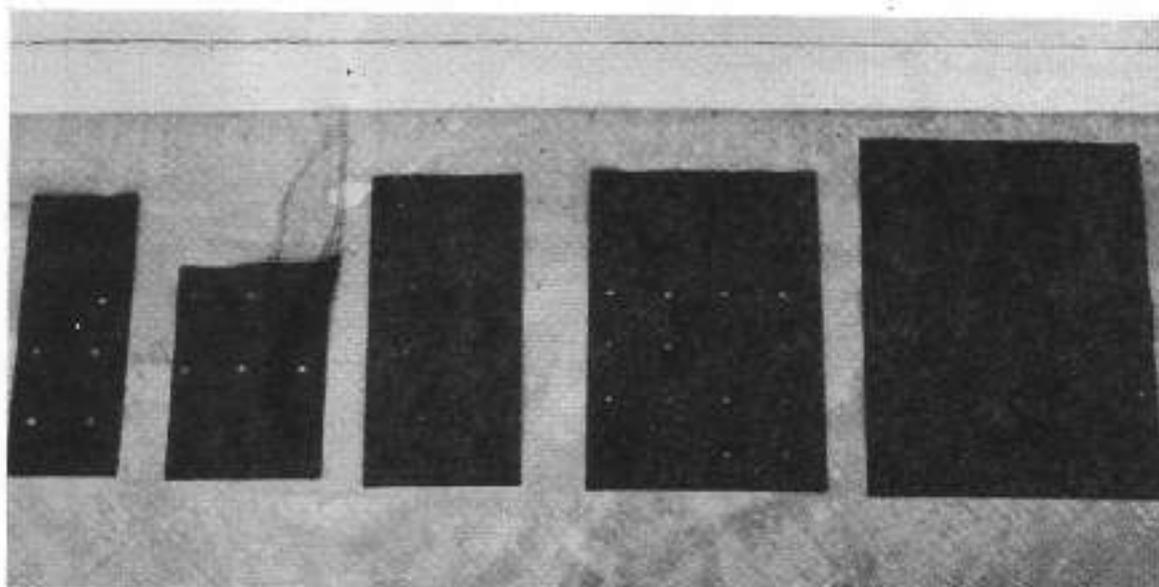
Ordinarily, we select a container according to its necessary capacity for seedling growth.

In the nursery other qualities are taken into consideration as follow:-

- (a) Durability or strength of the material to hold the plant and the potting of mixture.
- (b) Reasonable cost of the container.
- (c) A size that is easy to handle.
- (d) has good drainage, or holes can be punctured easily.
- (e) Availability.

Recently, polyethylene bags have been commonly used by nurseries in tropical areas.

Figure 15 Sizes of polyethylene bags (From left 3" x 8", 4" x 6", 4" x 9", 6" x 9", 8" x 12")



3.5.1 Potting mixture

(a) Soil

Well balanced and healthy growth is more readily achieved in soil with adequate organic matter, in which there are indications that useful growth promoting substances are also included.

It is most important to search out a really good source of top soil and have it analyzed.

Most frequently, it must be collected from outside the nursery. The soil must be taken from up to a depth of 20cm - 30cm from the top and must have a blackish colour. Before collecting soil, litter, grass, and roots on top of the soil must first be removed.

Top soil must be kept under shade, it must not be allowed to bake under the sun and it should be kept moist but not so wet that it will not flow easily when it comes to potting out.

The soil should be screened through a sieve to exclude roots, large stones, big clods of soil, and other impurities. The mesh of the sieve for screening topsoil is 1/2 inch. The soil must be forced through a fine sieve as this breaks down the natural crumb structure of the soil.

(b) Sand

Sand should be taken from a river bank or stream. It should be free from large stones and pebbles. Do not use sand contaminated with litter or mud. Sea sand is also not recommended.

(c) Compost

Generally, soil in tropical areas is clayey and contains less organic matter than soil from the temperate zones. In order to improve soil condition, it is recommended to mix compost into the potting mixture. Compost is a valuable form of humus plant food.

The influence of compost on soil can be categorized as follows:-

(1) Physical properties of soil

- I. Encourages granulation (better aeration).
- II. Increased water holding capacity.
- III. Reduced plasticity and cohesion.

(2) Chemical properties of soil

- i. Better supply and availability of essential potassium.
- ii. Increased absorption capacity.

(3) Biological properties.

Compost stimulates microbial activities in the soil. Compost can be made from various materials such as grass, rice straw, rice husks, wood bark, wood chips, sawdust and many others.

(4) Fertilizer

Production of healthy seedlings depend on adequate supply of plant nutrients. Generally, soil in tropical areas has poor fertility and so it is essential that some other organic element be incorporated into our potting mixture.

Mineral salts in commercial fertilizers adjust soil composition to meet the various plants requirements. The main elements or macronutrients of these commercial fertilizers are nitrogen, phosphorous and potassium (kalium).

The functions of these main elements or macronutrients are as follows:-

(1) Nitrogen

This is an essential element for protein building in plants. It greatly affects the vegetative growth of plants above the ground level. A deficiency causes poor growth of leaves and branches. The most prominent indication of a deficiency is leaves turning yellow. An excess of nitrogen makes the seedlings uselessly grow too quickly and turns the leaves dark green. An excess also lessens plant resistance to disease.

(2) Phosphorous

Phosphorous is essential for metabolic energy affecting the diameter growth of plants, even if plants grow by cell division. Phosphorous strengthens the tissue of branches and leaves by increasing their power of resistance to disease. Phosphorous is often lacking in acidic soils in particular, and its deficiency turns the leaves a grey green, blue violet or in pines, an older copper colour. It promotes flower, fruit and seed production but in extreme quantities it prevents the growth of roots.

(3) Kalium (Potassium)

Kalium is essential for metabolic reactions, especially protein building and transphosphorylation. It accelerates assimilation, strengthens tissue of leaves, and increases resistance to disease and pests. A kalium deficiency turns leaves dark green or grey, and produces blue spots on the foliar surfaces, thereby causing the leaves to wither and the tips of shoots to grow more slowly. It also slows the growth of roots. The natural supply of kalium somewhat exceeds that of

the nitrogen and phosphorous.

(4) Calcium

Calcium is essential for metabolism but it is not incorporated into fabric molecules. Calcium has important effects, such as the correction of soil acidity, the improvement of soil structure, the movement of carbohydrates, the neutralization of organic acids, and the formation of chlorophyll.

Calcium is easily washed away by water, especially in the tropical nursery. This is due to concentrated heavy rains in the rainy season. Deficiency in calcium lowers the rate of growth in seedlings, especially the growth of roots and turns leaves yellow. An excess supply of calcium changes the properties of the soil.

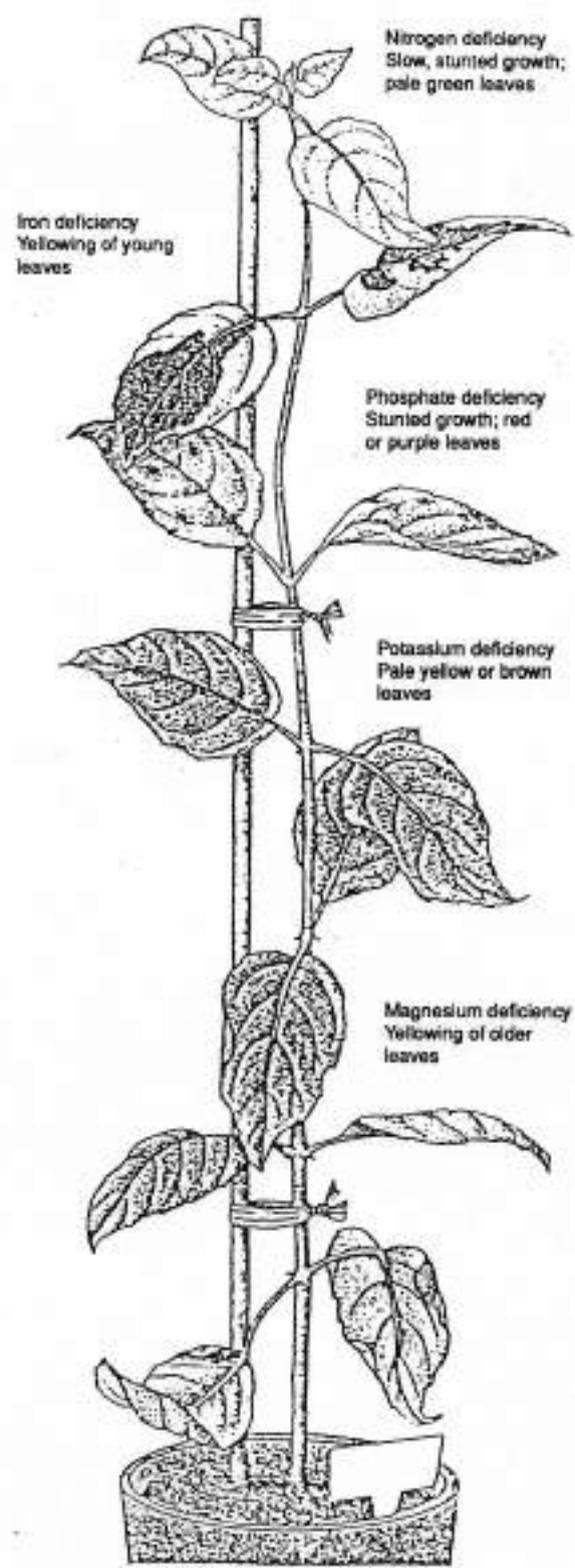
(5) Others (Trace elements)

Micro-nutrients or trace elements are essential for some enzymic reactions, which in turn are necessary for growth. Manganese, boron, iron, zinc, copper, and many others are present in the smallest amounts in common soil.

Table 5 List of compound fertilizers available

Name	Contents (%)			
	N2	P2O5	K2O	Mg
NPK-Blue	12	12	17	2
NPK-Green	15	15	15	-
NPK-Yellow	15	15	6	4

Figure 16 Illustration on fertilizer deficiency



3.5.2. Mixing

Components and proportions of the potting mix depend on the condition of the topsoil, and the requirements of the species to be planted.

If the topsoil has good texture, there is no need to add sand, compost, or even fertilizer.

Good topsoil texture greatly influences the amount of water that can be stored in the soil for plant use and the rate at which water moves through the soil.

In most cases, good texture indicates a fair amount of organic material.

Table 6 Capacity of polyethylene bags

Measurement in inches	Capacity in ml.	No. of pots can be placed one m ²
3 x 8	350	400
4 x 6	470	225
4 x 9	750	225
6 x 9	1,700	100
8 x 12	3,500	58

Example: Method in calculation of volume

The components of our standard potting mixture are:

- a. Topsoil 70%
- b. Sand 20%
- c. Compost 10%
- d. Fertilizer 1 gram per pot 4" x 6"

The example below shows how to calculate component quantities for potting mixture to be used for producing 10,000 potted seedlings in 4" x 6" polybags.

$$V = \frac{C \times N \times MR}{SR}$$

Where:

- V = Volume of each mixture (m³)
- C = Capacity of polybag (see Table 6)
- N = Number of seedlings required
- MR = Mixing rate
- SR = Probable survival rate from pricking to planting-out time (here estimated at 80%)

Example:

$$\text{Top soil} = \frac{0.00047 \times 10,000 \times 0.7}{0.80} = 4.11 \text{ (m}^3\text{)}$$

$$\text{Sand} = \frac{0.00047 \times 10,000 \times 0.2}{0.80} = 1.18 \text{ (m}^3\text{)}$$

$$\text{Compost} = \frac{0.00047 \times 10,000 \times 0.1}{0.80} = 0.59 \text{ (m}^3\text{)}$$

$$\text{Fertilizer} = \frac{10,000 \times 1 \text{ gram}}{0.8} = 12,500 \text{ gram} \\ = 12.5 \text{ (kg)}$$

3.5.3 Filling

The polybags should be filled with potting mixture only a few days in advance of transplanting or sowing, because if pots containing potting mixture are prepared a long time before, the potting mixture will develop into a hard clod.

Pot filling should be done under a roof, with the help of a handy scoop.

When filling, the polybags should be tapped occasionally to ensure that all the space inside is filled, leaving as few air spaces as possible.

This process will also compact the soil slightly so that the transplanted seedling will be left intact and upright after the first few watering in the nursery.

Filling mixture should also reach the edge or the mouth of the polybag to prevent the edge from bending or folding inside hindering watering.

Normally one worker can fill more than 500 4" x 6" polybags a day.

3.6 Pricking

Pricking means the transplanting of the young seedlings from the sowing boxes to the pots. Normally from two to five days after sowing, the seeds start to germinate. When these seedlings are one or two weeks old, they will have seed leaves, and from this time they can be transplanted or pricked. Leaving the seedlings too long in the sowing boxes allows the seedlings to produce lateral roots which will make it difficult to transplant them to the pots.

The seedlings are then removed from the sowing boxes with the help of a dibber. This is used to prevent the roots which are already formed from being broken. To make the transplanting job easier, the seedlings are placed in a plate filled with water to prevent them from wilting too fast.

The basic rules for pricking are as follows:-

- (1) The process of pricking is a shock to the seedling, so pricking must be done under shade and, when finished, newly potted seedlings must be protected from direct sunlight for several days or so.
- (2) The soil in the pots or in the potting beds must be moist but not wet.
- (3) Each plant must be lifted carefully using the dibber and lowered into a hole in the potting mixture.
- (4) The roots should not be tangled and should hang straight and vertical in the hole made.
- (5) The root collar must be at or just below the level to the soil surface.
- (6) The soil beside the hole is then pressed lightly around the roots so that the seedling sits firmly in the pot.
- (7) The pots must be watered to keep the soil moist, but must be watched carefully to avoid waterlogging.

Figure 17 Illustration on pricking



3.7 Shading

Shading affects watering as it decreases plant and soil temperature thus reducing evaporation stress. But even in shaded areas, soil temperature can rise to lethal or near lethal levels that can impair the growth of young seedlings.

The need for shading differs from species to species, stage of seedling development, and nursery location. Tiny seedlings are usually very tender and full shade is needed over pots or nursery beds. Shade is then gradually reduced, with the reduction rate depending on the species.

The following are SAFODA's guidelines for shade control:-

Acacia mangium

- | | | |
|-----------|---|-----------------------------------|
| 75% shade | - | for the first week in the polybag |
| 50% | - | for the 2nd to 3rd week |
| 0% | - | after 4th to 5th week |

Eucalyptus deglupta

Shading over seedbeds

- | | | |
|------------------|---|--------------------|
| 75% - 100% shade | - | first week |
| 50% | - | 2nd and 3rd week |
| 10% | - | after 4 to 6 weeks |

Shading for seedlings in polybags

- | | | |
|-----------|---|-------------------------|
| 75% shade | - | 1st week in the polybag |
| 50% | - | 2nd to 3rd weeks |
| 0% | - | 4th to 6th weeks |

Gmelina arborea

- | | | |
|-----------|---|-----------------------------|
| 75% shade | - | 1st week in the polybag |
| 50% | - | 2nd to 3rd weeks in polybag |
| 0% | - | 4th week in polybag |

Albizia falcataria (Paraserianthes falcataria)

- | | | |
|-------------------|---|------------------|
| 75% or more shade | - | 1st week |
| 50% | - | 2nd to 4th weeks |
| 0% | - | after 4th week |

Pinus caribaea

- | | | |
|-----------|---|---------------------------|
| 75% shade | - | for 3 weeks in polybags |
| 50% | - | for another 3 weeks |
| 0% | - | after 6 weeks in polybags |

3.8 Watering

Provision for an adequate water supply is essential in the nursery. Its primary importance lies in the fact that plants need water for growth. Water is necessary for photosynthesis, and for assisting plants to absorb mineral elements from the soil. Watering is equally important to offset the effects of evaporation, which can cause plants to wilt and even die.

Even in humid equatorial regions, with high, well distributed rainfall, one or two days drought can kill young seedlings. Newly pricked seedlings must never dry out, but neither should they be too wet. Soil should be moist and must be without rain; young plants have to be watered at least twice a day, in the early morning and late in the afternoon. Watering potted seedlings too much may cause root decay.

Here are some helpful recommendations for watering nursery plants:-

- (a) Sandy soil needs more water than heavy soil, as loose sand can not hold water and prevent it sinking through the soil beyond the plant roots. Water also evaporates easily from sandy soil.
- (b) Big leaved plants or shallow rooted plants need watering more regularly than small leaved plants or deep rooted plants. Water is lost through transpiration.
- (c) Damping off might occur if seedlings have too much water.
- (d) Use a fine spray nozzle for young transplanted seedlings to prevent pushing them over or washing away soil.
- (e) Keep the spray nozzle moving constantly to ensure even watering.
- (f) Ensure that a responsible person is available to supervise the watering, even during weekends and holidays.
- (g) Always make checks during and after each watering to ensure the day's schedule has been completed.

4. VEGETATIVE PROPAGATION

At this Project, the correct ways of cutting, grafting and marcotting is being studied. Especially for SAFODA staff, it is important to understand the vegetative propagation. Because there are superior trees of candidate-plus-tree of *Acacia mangium* and Acacia hybrid in SAFODA. These trees remark great potential as a fast growing species for future purposes. It is not only views a fast growth on sitable suite but its quality can be a fundamental stone towards the property and the main income of the country. We think that to propagate these trees is very important. It is possible to produce by collected seeds and sowing. But these trees also has a possibility of crossing with poor tree. If we collected seeds and sow it we can not produce the seedling which gaining quality of superior trees. So, to recur the wood quality, a few trials have to be made to propagate this species through a vegetative means. The way which gain the quality and for mass production of the seedling of superior trees, we can use vegetative propagation ways.

Thus, we simply order to this ways and classify to advantages and disadvantages.

Figure 18 Method of plant propagation

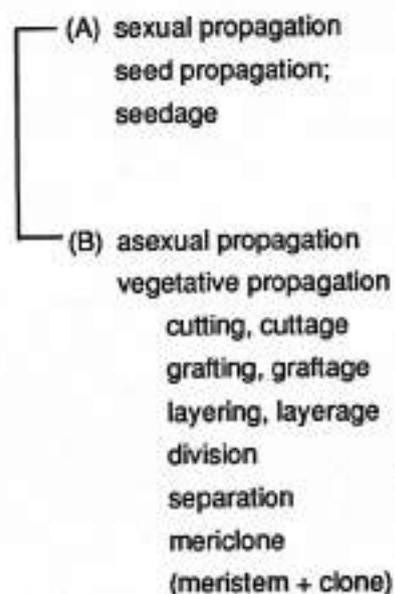


Figure 19 Kinds of Propagation method

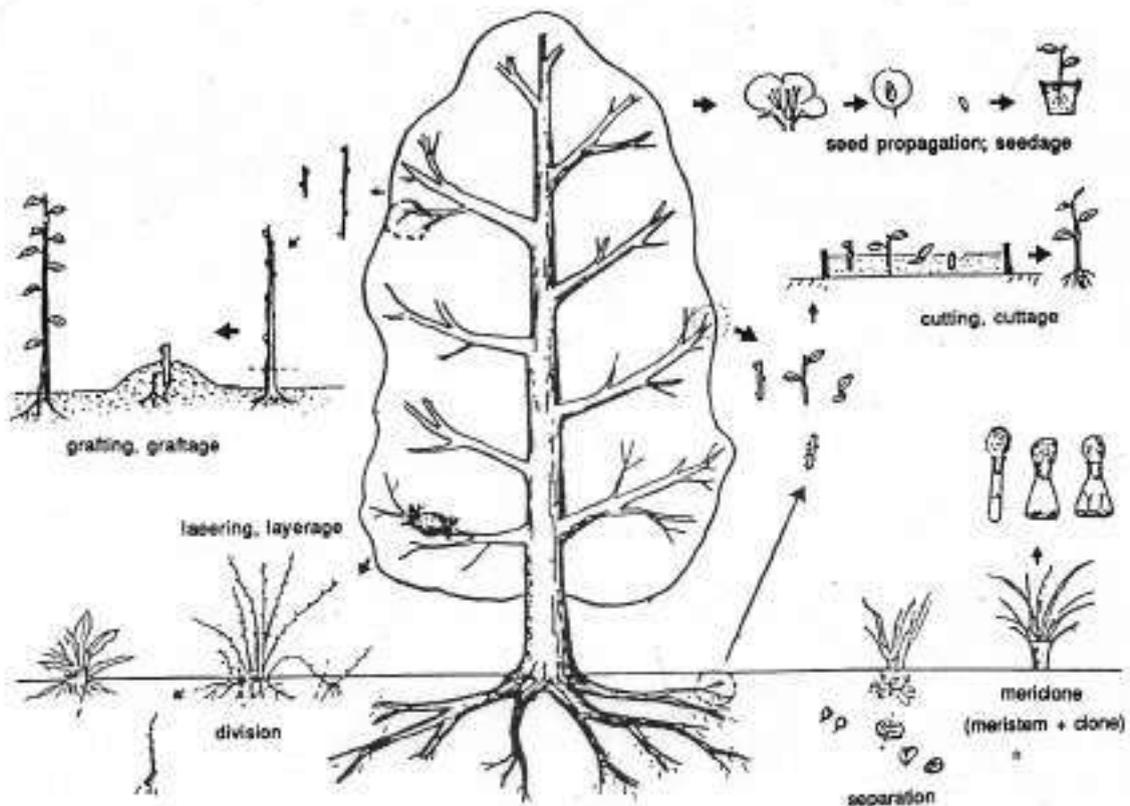
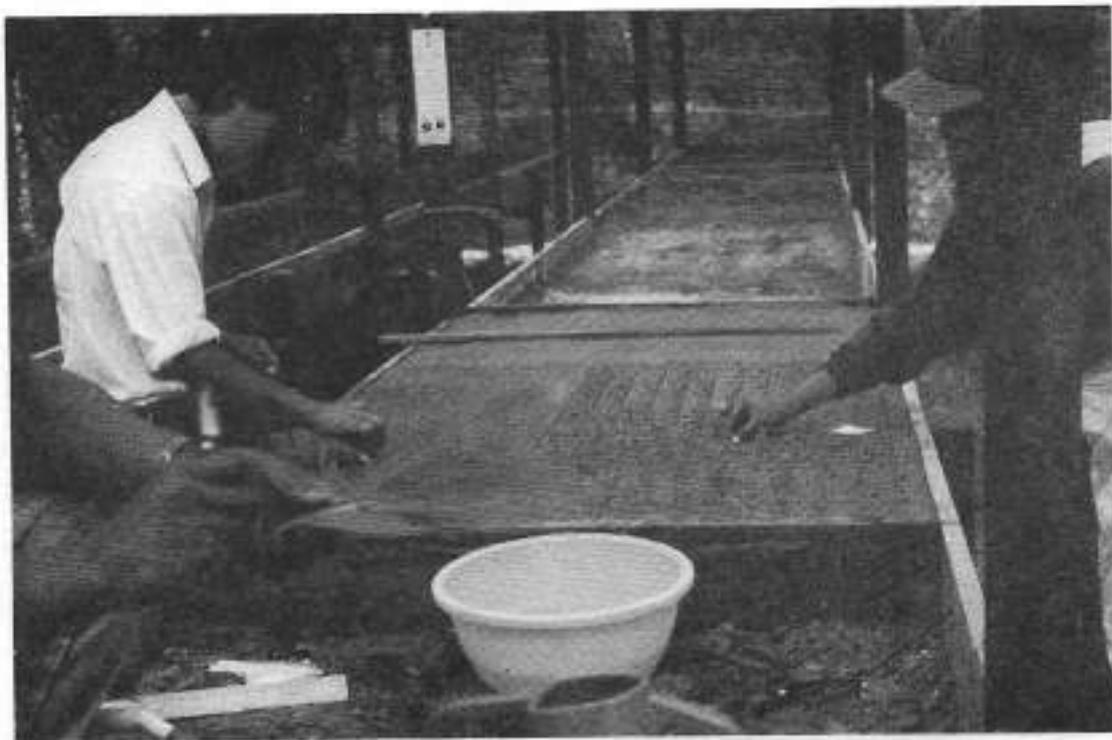


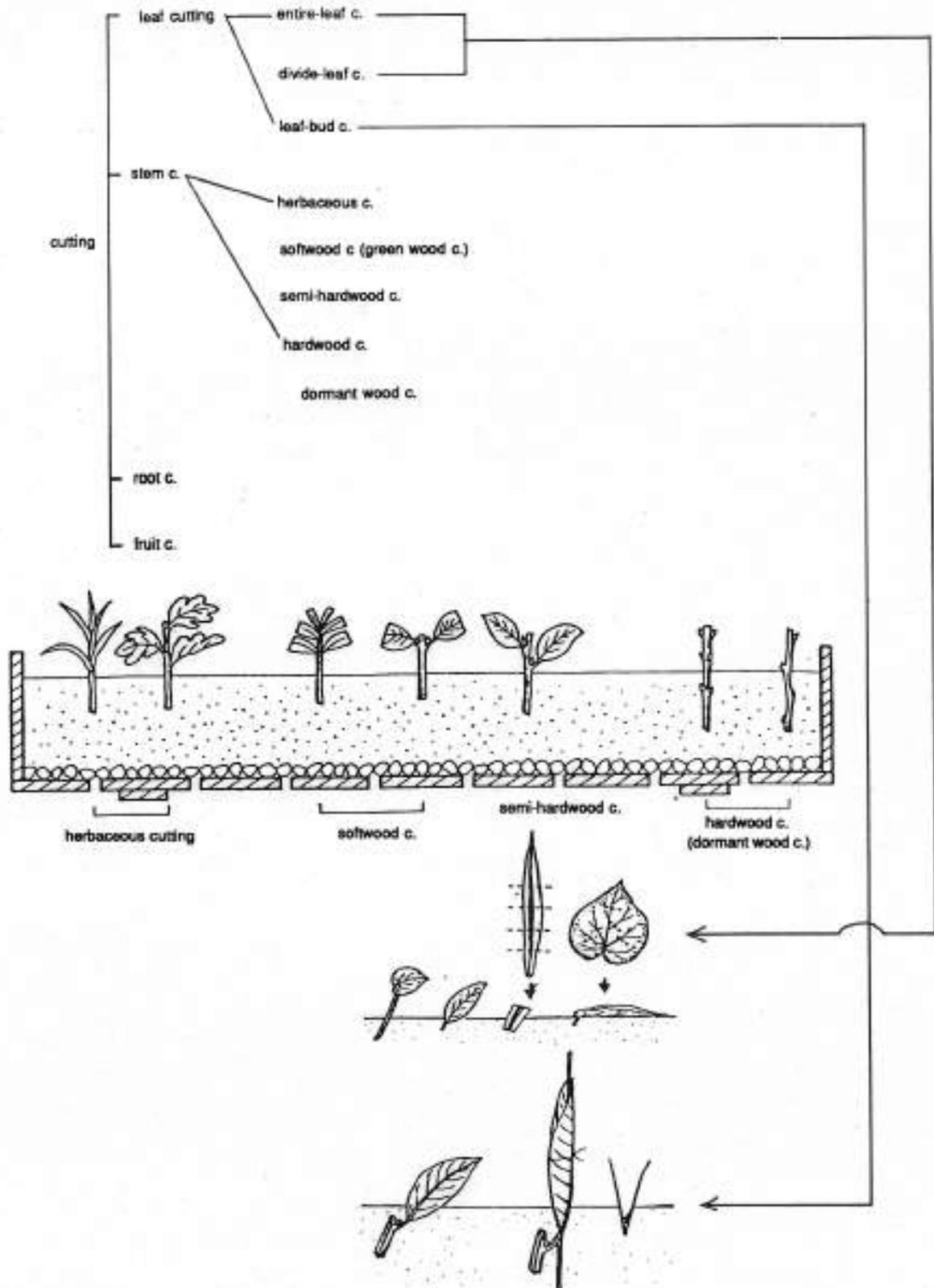
Figure 20 Illustration on Acacia Mangium cuttings



4.1 Cutting

Cutting is one method of vegetative propagation. In this method, a new plant grows by developing adventitious roots and shoots from a piece of plant.

Figure 21 Different Kind of cutting method



4.1.1 Advantages and disadvantages

(1) Advantages

- a. The genotype of the parent tree can be passed on to the progeny.
- b. Propagation can be achieved regardless of seed yield, and even when the parent trees have high sterility.
- c. The cultivation period in the nursery is shorter than that of seedlings.

(2) Disadvantages

- a. It is difficult to obtain large amount of cuttings at once.
- b. Some species and varieties can not be rooted easily. Producing cuttings of such trees on a commercial basis is difficult.
- c. Rooting is difficult in locations which are too hot, too cool, or too dry. Costs are high in nurseries lacking these ideal conditions.

4.1.2 Scion (For Hardwood cutting)

(1) Collecting scions

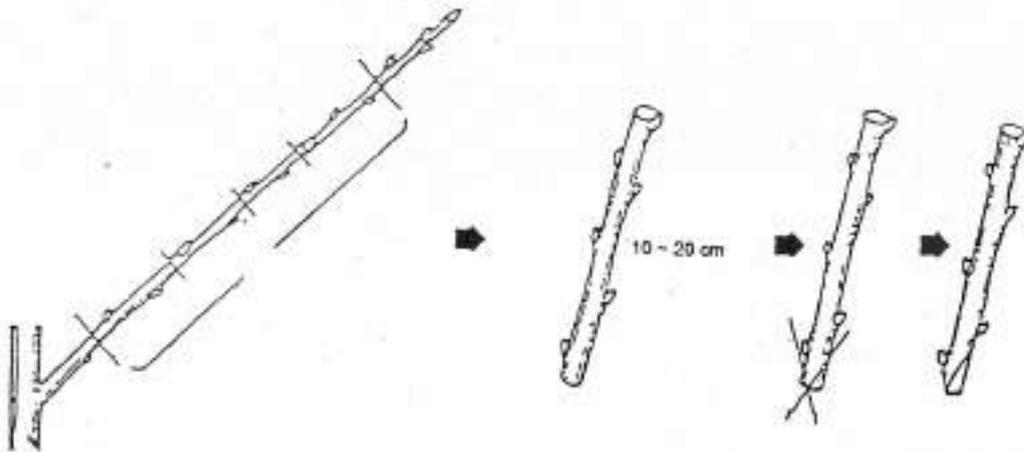
- a. Collect from young trees with good genotypes.
- b. Choose a shoot which has spread twigs on every side.
- c. Avoid wide internodes and withered shoots.
- d. Choose healthy scions.
- e. Choose a branch on which the terminal shoot is growing up steadily.

** It is beneficial that collected twigs are 10cm to 15cm longer than actual scion at the time of planting.

(2) Scion trimming

- a. Cut off a section of scion with a sharp knife.
- b. If the twigs are growing irregularly, trim them into a well-balance form.
- c. Soak scion in water to protect it from drying out.
- d. When using growth hormones, it is effective to treat the twig just prior to making a scion, and then plant it immediately.

Figure 22 Trimming of scion (For hardwood cutting)



4.1.3 Chemical treatments to promote rooting.

a. Growth hormone treatments

(a) naphthalene acetic-acid.

(b) Indole acetic-acid.

b. Vitamins and saccharoids

Vitamins: vitamin B1, vitamin H (biotin).

Sachharoids: cane sugar, grape sugar, fruit sugar.

c. Root stimulants

Hot water, ethyl alcohol, potassium permanganate, silver nitrate.

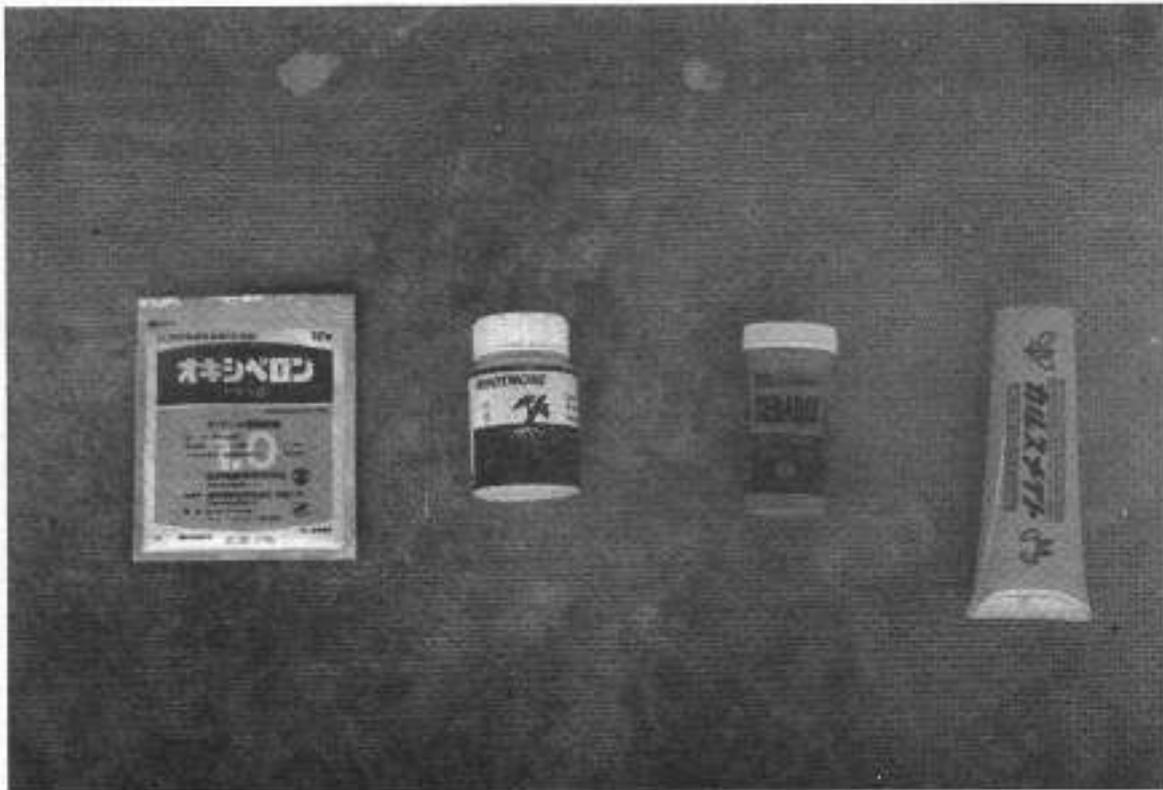
d. Antiseptic preservatives

Lime, alcohol, Bordeaux mixture, organic mercury.

e. Transpiration control

Mieron, Greener (commercial names).

Figure 23 Hormane and chemicals to prevent evaporation



4.1.4 Cutting bed

- (1) Cutting-bed environment
 - a. no strong wind.
 - b. sufficient atmospheric humidity.
 - c. suitable amount of sunlight.
 - d. convenient water supply
 - e. convenient layout for working.
- (2) Bed soil (rooting medium)
 - a. high water-holding capacity.
 - b. well-drained.
 - c. good permeability of air
 - d. free from rot, fungus and pests.

4.1.5 Scion planting

(1) Density of planting

Standard planting density per one square meter: Long scion more than 30cm: 100 - 130 cuttings Shorter scion: 160 cuttings.

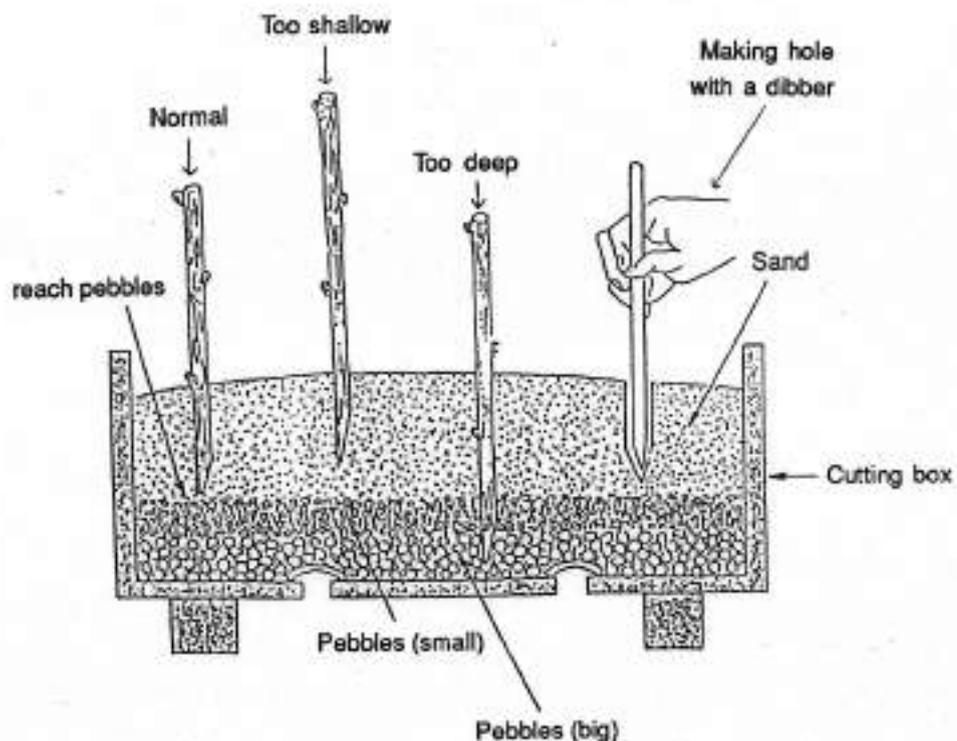
(2) Types of planting

- a. direct planting
- b. planting with a guide stick
- c. furrow planting

(3) Depth of planting

It is better to plant relatively deep in quick drying soil, such as sandy soil, and to plant shallow in humid soil. In the former case, scions are planted at a depth of $\frac{1}{3}$ - $\frac{1}{2}$ their length. In the latter case, plant at a depth less than half the scion length. Generally scions are planted 8 - 12 cm deep.

Figure 24 Planting scions (For hardwood cutting)



4.1.6 Management after planting

(1) Watering

As the transpiration of a scion is rapid for one or two weeks after planting, and water balance is unstable, close attention must be given to watering.

(2) Sunshades and windbreaks

As sunshades control evaporation from the ground and transpiration from the surface of leaves, they are as important as watering. When planting in the open-air, windbreaks are also useful for same reason.

4.2 Grafting

Grafting is the operation of inserting a plant part, such as a twig, bud or root, into another plant or plant part. The result is a new plant, propagated vegetatively by the joining of scion and stock.

4.2.1 Advantages and disadvantages

(1) Advantages

- a. It is possible to reproduce species that can not be reproduced easily from seeds or cuttings.
- b. It is possible to reproduce plants whose genetic line is difficult to preserve when propagating from seeds or cuttings.
- c. It efficiently modifies twig systems and recovers growth vigor.
- d. A cardinal advantage is that a variety or species with better characteristics than that of the scion plant can be selected for use as the stock.

For example, stock might be selected:-

- (a) to stimulate flowering.
- (b) to gain more resistance to diseases and insects.
- (c) to improve environmental adaptability.

(2) Disadvantages

- a. Operator needs to be skilled in grafting techniques.
- b. The problems of grafting affinity between scion and stock must be solved.

- c. It is difficult to produce a large scale plantation at once.

4.2.2 Classification of grafting methods

- (a) Scion grafting
- (b) Budding
- (c) Inarching

Scion grafting is always employed for the propagation of forest trees.

Figure 25 Illustration of grafting methods

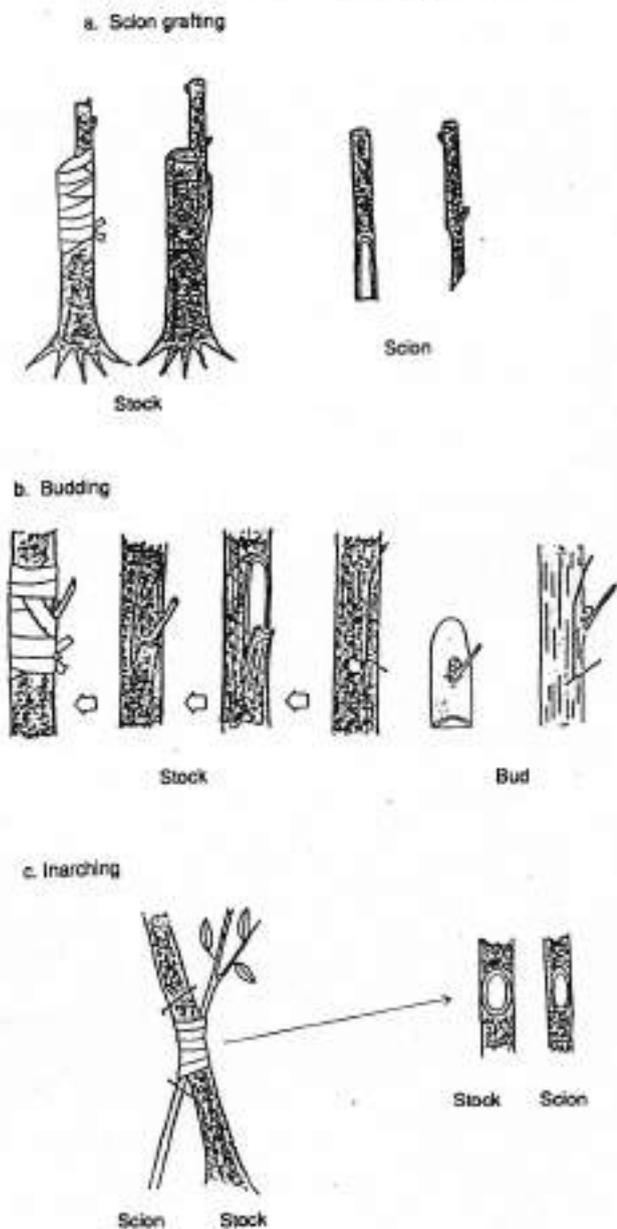
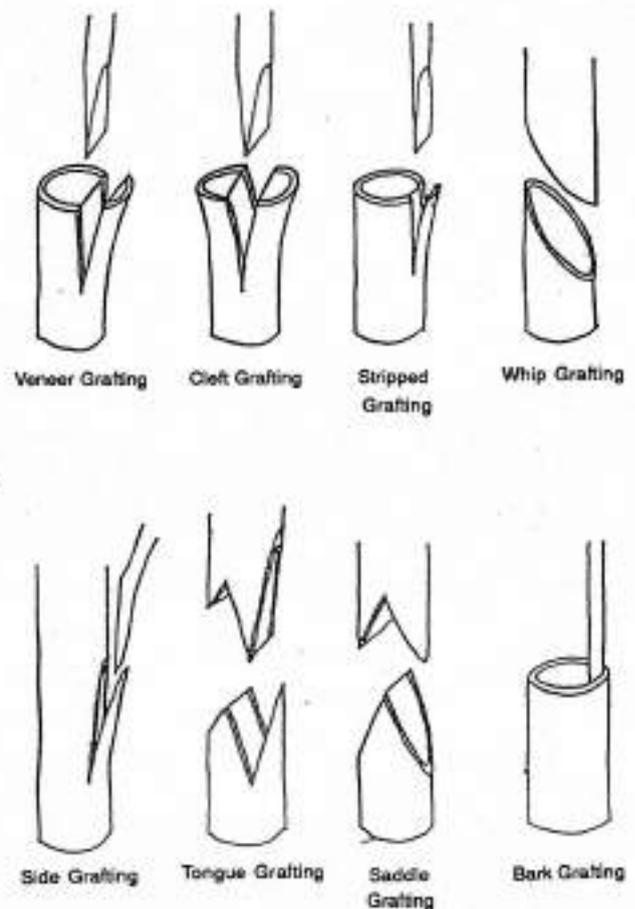


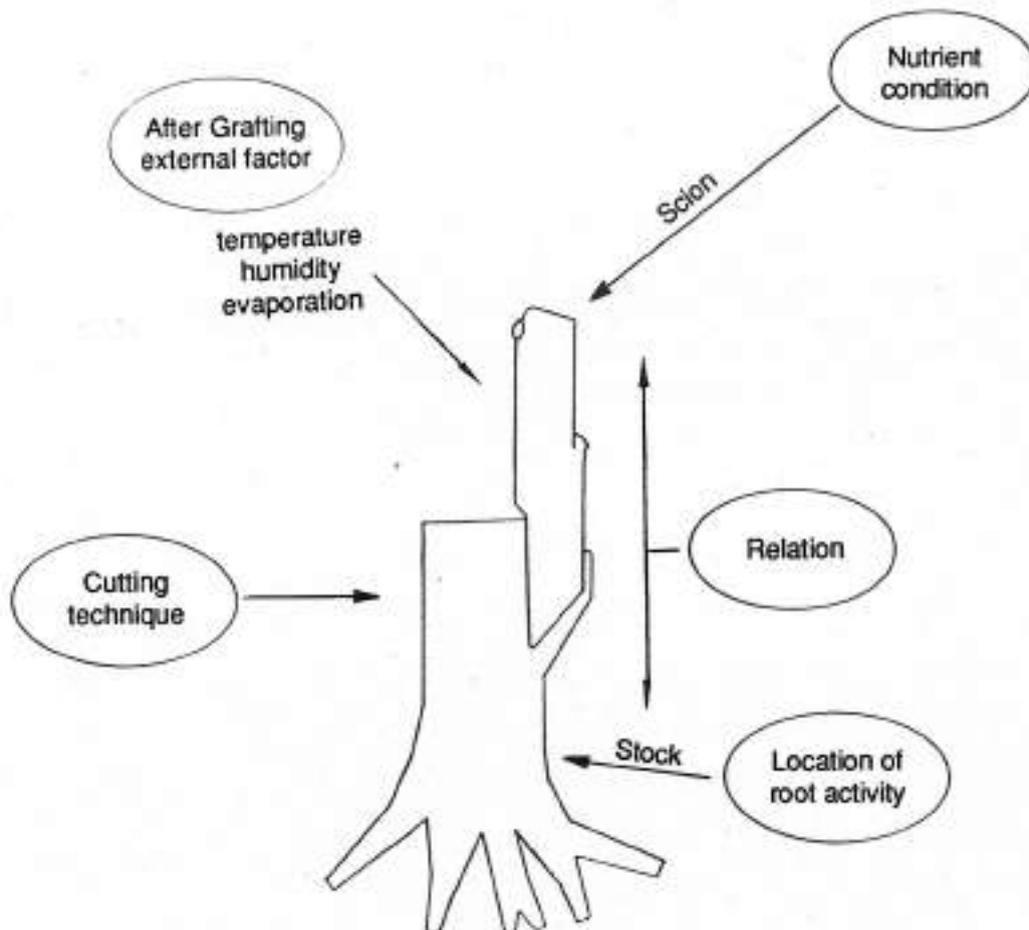
Figure 26 Ways of scion grafting



4.2.3 Grafting affinity

Affinity means the ability to make a new plant by joining a scion plant to a rooted stock plant. In general, no stock scion incompatibility is expected if the scion belongs to the same species. Although many successful interspecific graftings are known, it is better to choose the same species as the scion as root stock.

Figure 27 Condition for success of grafting



4.2.4 Collecting scions

- (a) Collect from young and healthy trees.
- (b) Choose young branches which have vigorous shoots.
- (c) Eliminate epinastic branches (including lammas shoots).
- (d) Eliminate branches recognised to be bud-mutants.
- (e) Choose branches free from heavy disease and insect damage.

4.2.5 Grafting techniques

(1) Tools

- a. trimming scissors
- b. grafting knife (budding knife)
- c. wooden box for grafting

(2) Rolling materials

Rolling materials are used to attach the scion to the stock. In principle, it should be a material not made elastic by changes in humidity, be easy to roll, and rot naturally when the grafted tree begins to grow. Some of the materials used are as follows:-

- a. straw
- b. tape of some material
- c. wax cloth, wax paper
- d. rubber bands

(3) Wrapping materials

Wrapping materials are used to protect the joined point from desiccation and the intrusion of rain water. Some examples are:-

- a. soil
- b. grafting soil (clay + straw waste)
- c. leaves

d. **grafting wax**

(4) Order of grafting operations

- a. **Slant-cut the scion**
- b. **Cross cut the scion, to make another cut across the first slant-cut, making a pointed end. Put it in your mouth to keep it moist.**
- c. **Cut-back the stock.**
- d. **Insert the scion into the stock, and join the cambiums together.**
- e. **Bind the cut portions together with plastic grafting tape, so that the cambiums are in close contact.**
- f. **Cover with polyethylene bag to protect it from evaporation.**

(5) Factors affecting success

- a. **The exposed cambial layers should match as closely as possible, at least on one side of the graft.**
- b. **The grafting knife should be razor sharp and all cuts must be done quickly with minimum damage to the cambium.**
- c. **It is desirable to keep the wound areas on both scion and root stock moist.**
- d. **The point of joining should be protected from desiccation for several weeks after grafting.**

4.2.6 Management after grafting

- (a) **Make a sunshade and wind break to prevent desiccation and overheating for several weeks after grafting.**
- (b) **Remove rolling or wrapping materials.**
- (c) **Trim root stock sprouts.**
- (d) **Erect props if the grafted part is not strong enough to support itself properly.**

4.3 Marcotting

This is a better treatment for making a scion garden. *Acacia mangium* and Hybrid trees are a little too hard to propagate through cutting clones of Candidate Plus Tree. Of course, they can use for establish seed orchard or progeny test forest.

4.3.1 Method

Firstly we have to choose most suitable branch from mother tree. And then, young branches with a diameter of 2.5 cm to 3 cm are selected and girdled with a sharp knife. The girdled area is covered with sphagnum moss, which is well aerated, holds water and readily manipulated. The size of a large fistful when this moss is squeezed into a ball is enough to cover the girdled branch. Wet the moss and secure it with a polythylene sheet, secure it to the branch by turning a tape spirally around the ends of the polythylene sheet overlapping ends until it covers part of the branch. The polythylene sheet will help retain moisture, and sunlight must be excluded so shade of paper (newspaper will do) must cover the marcotted part.

Figure 28 Illustration of Marcotting



4.3.2 Advantages and disadvantages

(1) Advantages

- a. To succeed superior quality of parent.
- b. To easily make clone.
- c. To surely root than cutting.
- d. To possible get big size stem.

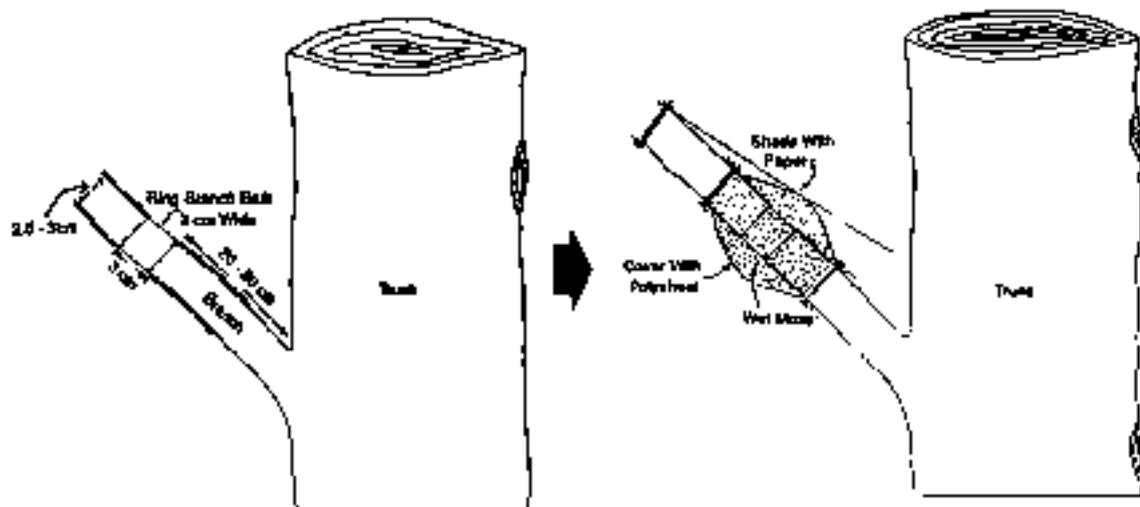
(2) Disadvantages

- a. Can not get many seedlings at one time.
- b. May be dangerous to climb to a tree.
- c. Need careful maintenance.

4.3.3 Management after marcotting

Moisture content of moss should be checked at least once a week, if dry then it needs to be wetted again.

Figure 29 Marcotting illustration



5 PESTS AND DISEASES OF NURSERIES

5.1 Insects and other animal pests.

The largest group of the animal kingdom is the Arthropoda derived from the word "arthropod" which means "jointed foot". It includes the Arachnida (mites, spiders, etc.), and the Insecta (also known as Hexapoda or six-footed), (grasshoppers, butterflies, etc.). A few kind of arachnids and many kinds of insects prey on nursery plants, i.e. seedlings and may cause damage to them. Larger animals may also injure seedlings.

5.2 Insects

The insects ("insect" may be translated "in segments") include more species than all other groups of animals and plants together. The body of an arthropod is composed of a number of more or less similar segments arranged in series. Some of the segments bear jointed legs. The body of an adult insect is composed of three parts: head, thorax and abdomen. Each of these is composed of several segments, which may or may not be apparent. On the head is a pair of antennae, which are sense organs. The thorax bears three pairs of legs and usually one or two pairs of wings.

The insect develops in a complex series of stages. The young offspring are often different from the adult. The immature grasshopper (the nymph) resembles the adult in a general way, but lacks wings. At each successive stage in development it resembles the adult more closely and is said to undergo a gradual or an incomplete metamorphosis. Most insects have a more complex life history. The egg laid by the female develops into a larva, a wingless wormlike caterpillar or grub which often feeds on foliage or other plant parts and increases rapidly in size. As it grows it periodically casts its skin. After this period of growth the insect becomes a pupa, a comparatively inactive and helpless body usually enclosed in some kind of cocoon. In this stage the body structure is reorganized and finally the imago or adult insect emerges. This sequence is said to be a complete metamorphosis and is found in butterflies, moths, etc. The followings are the most familiar groups of insects and include those that are most injurious to seedlings of nursery.

a. Orthoptera:

They have two pairs of wings of which the fore wings are somewhat thicker and cover the hind wings when they are at rest. The mouthparts are formed for chewings. The two most common grasshoppers encountered in the nurseries are *Stenocantatops splendens* and *Attractomorpha psittacina*, both belonging to the family Acrididae. These grasshoppers feed on the leaves of *Acacia mangium* causing only minor damage. They are active during bright sunshine.

A cricket, *Brachytrypes partentosus*, belonging to the family Gryllidae attacks newly germinated seedlings of pines by chewing off their stems. The adult cricket is about 2 - 4 cm long, brown with an exceptionally unsegmented, long antennae. They live in burrows or under pieces of trash and emerge at night in search of food, part of which may be carried back.

b. Homoptera

Two species of insects, jumping plant lice, belonging to the family Psyllidae and leaf hopper belonging to the family Cicadellidae infest seedlings of *Acacia mangium*. The mouthparts of both species are adapted to piercing and sucking. The symptoms produced by jumping plant lice include profuse production of both shoots and young leaves. In severe cases, the plant becomes stunted. Attack by leaf hopper results in slight curling of the leaves and yellow spotting which may be elongated or circular. Plant may also become stunted. Leaf hoppers sometimes carry virus and the symptoms of yellow spotting are typical of virus attack.

c. Coleoptera

Two types of beetles, *Adoretus compressus* Webr. belonging to the family Rutelidae and *Apogonia* sp. belonging to the family Scarabaeidae feed on the leaves of *Acacia mangium* seedlings. They hide in the soils during the day and feed mainly at night. Infestation is seldom heavy as plants can produce new leaves at a faster rate and therefore compensate for any leaf loss by defoliation.

Another beetle, *Hypomecas squamosus* Fabr. belonging to the family Curculionidae infests the foliage of *Acacia mangium* seedlings. An infested seedling shows sign of leaf defoliation of varying degrees. The beetles possess a short rostrum and body covered with powdery substance. Female beetles are more darker than males. The beetles have the habit of pretending dead when disturbed, i.e. dropping on the ground with legs and antennae folded.

d. Lepidoptera.

The caterpillars of yellow butterflies, *Eurema blanda* Boisduval and *Eurema hecabeae* Linnaeus belonging to the family Pieridae defoliate mimosa-like leaflets of young *Acacia mangium* seedlings. Sometimes damage is so severe that the stem is completely cut off resulting in death of the seedling. The caterpillars are green in colour with black heads and are approximately 25 mm in length. Pupa of both species may be parasitised by a fly, *Beachymeria* sp. (Order: Hymenoptera, Family: Chalcididae).

5.3 Animal pests

Pests other than those of insects may also be found in nurseries. The followings are some examples of animal pests.

a. Acarina

A species of mites, *Bravipalpus* sp. belonging to the family Pseudoleptidae infests leaves of *Acacia mangium* seedlings. Infestation is favoured by dry weather and usually disappears with the coming of the rains. They have four pairs of legs and usually feed on the under side of the leaves by means of sucking mouthparts. The shoots and young leaves of the affected plants become curled and develop yellowish spots especially along the veins of the leaves. In severe cases, leaf

defoliation occurs and the plants become stunted.

b. Pulmonata

A species of slug, *Vaginula* sp. is very common in nurseries whose conditions are always damp and wet. This moist condition as well as the production of slimy secretion in which it covers itself give adequate protection against the sun. They cause extensive damage by chewing off apical stems of young *Acacia mangium* seedlings. They are about 2-4 cm long and are dark brown in colour. The giant snail, *Achatina fulica* is known to feed on the leaves of *Sweetenia macrophylla* seedlings. Both slugs and snails live in sheltered places such as low vegetation and leaf litter, sheltering by the day and come to feed at night.

c. Rodentia

A species of rat, *Rattus argentiventer* R. & S., feeds on germinated seeds of pines. In some cases, losses up to 100% have been recorded in some nurseries.

d. Other animals

Some nurseries being very close to human dwellings are often visited by domestic animals such as buffaloes, dogs, cats and chickens. Buffaloes tend to damage pots and seedbeds by trampling on them. Dogs may chase cats and if left unchecked may damage seedlings during their flight. Chickens can damage young seedlings if allowed to peck around the seedbeds.

5.4 Plant Diseases

Any condition that interferes with normal development of a plant is said to be a disease of a plant. Development is normal when it is typical of the particular kind of plant. The growth of the stem, branches and roots, the unfolding of leaves of a certain shape and size, the formation of characteristic flowers and fruit, the manufacture of pigment, food, fibers, etc. are all phases of normal development. If the stem is stunted, if the leaves are curled or mottled or spotted, if the plants wilt, if green colour is lacking, if the flowers are of an unusual form or colour, etc. or if plant manifests any other abnormalities in its development, then it is said that the plant is diseased.

The causes of plant diseases may be divided into two main groups, i.e. parasitic and nonparasitic. The former include fungi, bacteria, viruses and nematodes. The nonparasitic causes include deficiencies or surpluses of nutrients, lack or excess of moisture, extremely low or high temperatures, chemical substances in the soil or atmosphere and mechanical and electrical agents, the followings are some classification of plant diseases.

5.5 Diseases classified by symptoms

Plant diseases may be classified according to their symptoms, i.e. spots, blights, rots, etc. Although plant diseases may be manifested by the same symptoms, the causal agents may

entirely be different and therefore require different methods of control.

a. Spot Diseases.

Spots on foliage are common evidence of diseases and are caused by various fungi. Both seedlings of *Acacia mangium* and *Paraserianthes falcataria* are susceptible to leaf spots. This disease is characterized by the formation of necrotic areas on the infected leaves. The necrotic areas vary both in size and shape, i.e. from small to large and from circular to angular or irregular. Generally the spots are isolated but sometimes they coalesce giving a blotching effect to form big necrotic lesions. The four pathogenic fungi isolated from *Acacia mangium* and *Paraserianthes falcataria* are *Glomerella cingulata* (Sacc.) Spauls, et Schr. belonging to the group Ascomycetes and *Phyllostictina* sp. and *Pestalotiopsis* sp., both belonging to the group Deuteromycetes.

b. Blight

This is a disease that kills young growing tissues especially leaves and twigs. Pinus seedlings are usually affected. Generally the disease appears two months after the seedlings have been transplanted into the polybags. Yellow spots initially develop on the distal ends of the lowest needles. Crystalline secretion sometimes appear on the stem. Gradually the needles turn brown, then drop and later fall. The disease spread slowly up the stem, killing needles as they proceed. The infested plant loses vigour and becomes stunted because of stimulated dormancy of the terminal bud. Slightly infested plants will recover after fungicidal spraying but heavily infested ones will not likely to recover and will eventually die. The four pathogenic fungi identified include *Cercospora pini-densiflorae*, (Hori & Number) belonging to the group Deuteromycetes and *Pestalotiopsis* sp. and *Collectotrichum* sp., both belonging to the group Deuteromycetes. *Ceratomyces paradoxa* (Dade) Moreau belonging to the group Ascomycetes is also found in association with the disease.

c. Damping-off

Damping-off is one of the first disease commonly encountered in nurseries. They are caused by various fungi the most common ones being *Phytophthora* sp. and *Phythium* sp. both belonging to the group Phycomycetes. *Fusarium* sp. belonging to the group Deuteromycetes and *Rhizoctonia* sp. belonging to the group Mycelia sterilia also cause damping-off. The disease is considered of major importance as it sometimes causes 100% mortality of the viable seeds. However, only very young seedlings are attacked and after stem develops woody tissue, susceptibility begins to decline.

Acacia mangium, *Pinus caribaea*, *Gmelina arborea* and *Paraserianthes falcataria* are all susceptible to damping-off. Damage in nurseries occurs in two phases of the seedling development. In the pre-emergence phase, the germinating seeds are attacked below the soil level, while in the post-emergence phase, the seedlings collapse due to attack at just or below the ground.

d. **Rot**

An example of rot disease is charcoal root disease which is commonly observed in nurseries particularly in seedlings of *Acacia mangium*. The causative fungus is *Macrophomina* sp. belonging to the group Deuteromycetes, which invades root tips, lateral roots and collar region. The gradual destruction of root system causes the seedlings to become stunted and chlorotic and finally die. The disease is favoured by warm temperature so that shading and watering may reduce seedlings mortality.

e. **Mildews**

Powdery mildews are fungi that grow superficially on the leaves of *Acacia mangium* seedlings, causing a greyish fungus layer. In severe cases, the leaves of the affected plants become thick and leathery. This disease is caused by *Cladium* sp. belonging to the group Deuteromycetes.

f. **Scorch**

During very hot weather the sun's rays may cause a browning and shriveling of leaves. It may affect the tips and margins or involve the entire leaves. Such symptoms are called scorch or sunscorch. *Acacia mangium* seedlings exhibit sunscorch if shading sheets are not removed gradually.

g. **Wilt**

Wilt is due to a deficiency of water in the leaves and stems. This may be due to lack of water in the soil or injury to the root system. Rot of the roots or of the base of the stem can also cause wilting in *Acacia mangium* seedlings.

h. **Stunts**

Stunting of *Acacia mangium* seedlings may be due to attack by leaf-hoppers or by virus or to lack of proper nutrients in the soil.

i. **Mosaic**

The effects of viruses in *Acacia mangium* seedlings often appear as a mottling of the leaves. The leaves are marked with a pattern of light and dark areas forming a mosaic. Such symptoms are frequently associated with curling of the leaves and growth abnormalities.

j. **Chlorosis.**

Chlorosis occurs when leaves of seedlings become whitish or yellowish in discoloration. It may be caused by mineral deficiency or by virus.

5.6 Diseases classified by causes

I. Diseases due to environmental conditions or cultural practices.

a. Mineral deficiencies

Plants need a well balanced diet to grow well. Those grown in soil which lacks one of the major elements, such as nitrogen, phosphorus or potassium or one or more of the essential minor elements, such as iron, boron or magnesium will result in poor growth. Plants may become chlorotic because of the unavailability of iron. Stunting of plant occurs if boron is unavailable in the soils.

b. Chemical injuries

Faulty application of fertilizers may result in foliage at tops of seedlings becoming brown and scorched careless use of weedicides may result in death of seedlings. Weedicides contain hormone and are extremely difficult to remove from a spray tank. It is suggested that a sprayer be allocated only for the spraying of weedicides.

Insecticides and fungicides may damage seedlings if applied indiscriminately. Injury is most apt to occur on tender, succulent growth or when soil is dry. Wettable powders in water are usually safer than sprays made from emulsifiable liquid concentrates. However, wettable powders leave more prominent residues after spray application.

c. Sunscorch

The leaves of *Acacia mangium* seedlings may be scorched if gradual removal of shading sheets are not practiced. Sunscorch happens especially on warm windy days when water is lost more rapidly than it can be replaced through the roots.

II. Diseases due to fungi, bacteria viruses and nematodes

Most of the parasitic diseases of plants are caused by fungi. All plant seedlings are subjected to attack by fungi some of which cause little damage while others may kill them.

5.7 Control of pests and diseases of nursery

Control of pests and diseases of nurseries can be achieved by the following methods.

a. Cultural practices

It is a common knowledge that good cultural practices carried out in nurseries can avoid infestations of seedlings by insects and fungi. Potting mixture should not be

under or excessively fertilized. Similarly seedbeds should be sufficiently watered. Underwatering will result in charcoal root rot while over watering will enhance damping-off in *Acacia mangium*. Occurrence of plant diseases in nursery is enhanced in high humidity. Thus germinating house should be well ventilated and seedlings in the nursery properly spaced. Application of insecticides and fungicides should follow the recommended dosage as excessive application are not only harmful to plants but also wasteful.

b. Sanitation

Sanitation aims at eliminating or reducing sources of infestation whether due to pests or diseases. Ensure that seeds or other planting materials used for the nursery are healthy. If it has been known that tools have been used to work on diseased materials then they should be disinfected in 5% formalin solution. Many diseases are caused by fungi which live in the soil. The occurrence of damping-off can be prevented by heating the soil. Chemicals may also be used for the same purpose but the soils must be in good tilth and free from lumps. 'Thiram' so at 3g per square yard of soil has been used with success. In some nurseries, pipes are laid in seedbeds through which steam is introduced to destroy harmful fungi, nematodes, insects and weed seeds. Many pests and fungi survive in old leaves and garden refuse. Pests such as cricket, slug and snail live in piles of old leaves, so that destruction of such trash is obviously important in preventing infestation of seedlings in nursery. The same is true for many fungi. Fungi which infect leaves usually form spores which adhere to the leaf surface and remain alive even after leaf and the fungus mycelium within it have died. For this reason fallen leaves and twigs of plants should be raked up and placed in trash cans and carted away to be burnt or buried. Destructive fungi, such as *Fusarium* sp. which caused damping-off are also found in rubbish heaps, old leaves, mulch and the like. Similar precautions should be taken in the disposal of diseased parts which are removed from living plants. Sanitation also involves the control of weeds, for they are hosts to pests and fungi that attack seedlings in nursery. Slugs, snails and rats prefer to live where vegetation is abundant and destruction of such weeds will reduce their frequency of attacks.

c. Resistant varieties of plants

If there are resistant varieties of plants already available against particular insects and diseases, then these varieties should be chosen. However, breeding of a particular plant that is resistant against insects and fungi is difficult as pests and fungi are so variable in their pathogenicity. If such plant varieties are available then the use of insecticides and fungicides may become absolute or reduced.

d. Pesticides

These are chemicals used to combat and destroy pests. Those used against insects are called insecticides while fungicides are used against fungi. Pesticides may be in the form of sprays, dusts and fumigants. They must be poisonous to the pests but harmless (or nearly so) to the parts of plants with which they come in contact. The use of sprays by inexperienced workers often cause more damage to plants than the pests. It is most desirable that the dilutions of the pesticides used should be the lowest concentration that is able to kill the pests. A great

variety of pesticides has been used to combat pests. Naturally those that are best adapted should be used. Development of new pesticides is continuous and many new preparations have come on the market. Until they have been used for sometime and under various conditions, it is difficult to say whether they are more superior to some of the older products. However, in using any pesticides, old or new, it is important to follow the directions printed on the label

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