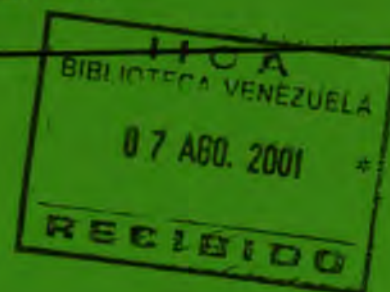


AGROFORESTRY IN GUYANA

GUIDELINES FOR ESTABLISHMENT AND MANAGEMENT OF
AGROFORESTRY PRACTICES



THORWALD GEUZE
PAULINE VAN DEN ENDE

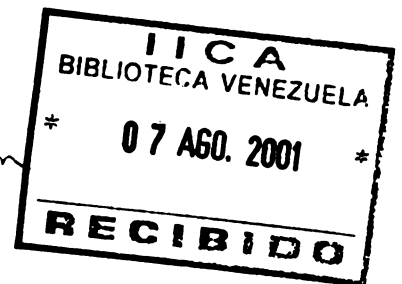


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Guidelines for Establishment and Management of Agroforestry Practices

**THORWALD GEUZE
PAULINE VAN DEN ENDE**

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Pauline van den Ende*



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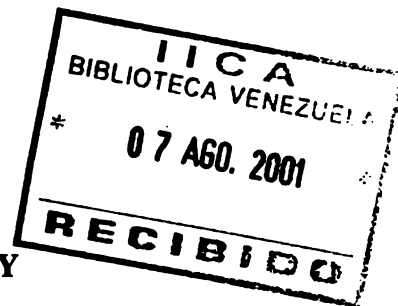
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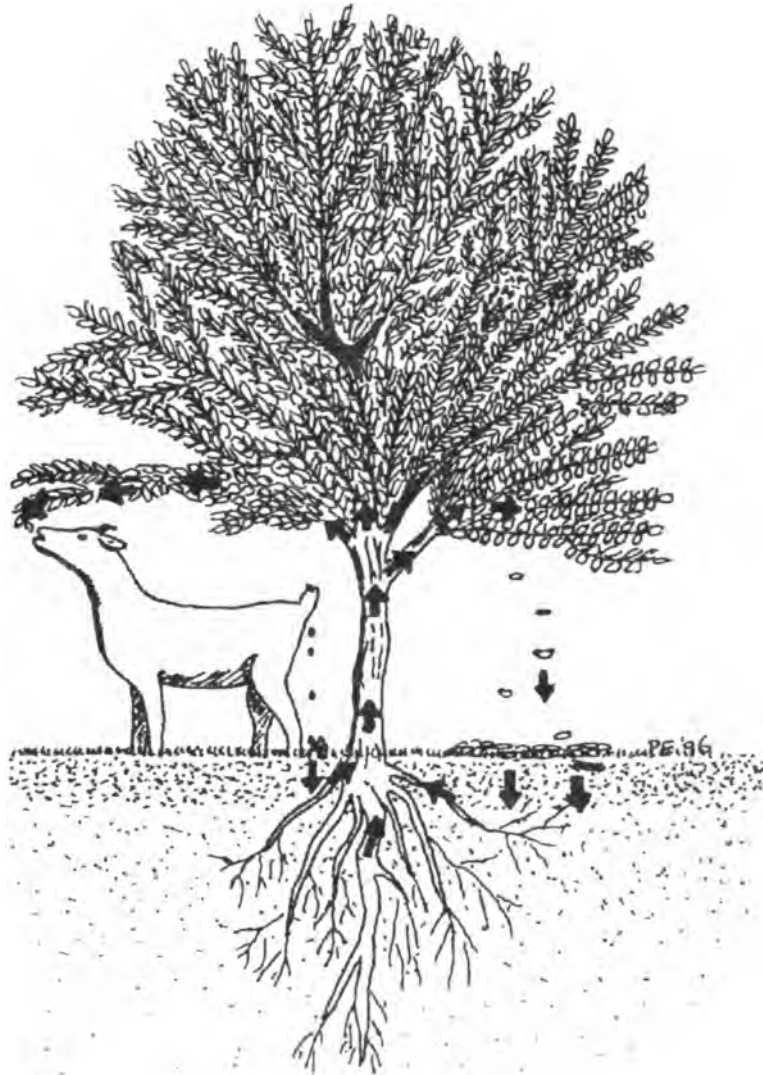
We hope the Guyanese people, used to Dutch names like Kyk-Over-Al, Beterverwagting and Abrahamzuil, will understand and forgive our Dutch-English.

Thorwald Geuze

Pauline van den Ende

CHAPTER ONE

INTRODUCTION TO AGROFORESTRY



INTRODUCTION

In Guyana, one can immediately distinguish two forms of agriculture. On the one hand there is the agriculture of the coastal plains, characterized by intensive cropping systems of predominantly rice and sugarcane. On the other hand there is the agriculture of the so-called hinterland dominated by staple crops like cassava, corn and plantains and some cash-crops like peanuts and pineapples. One of the main reasons for these differences are the differences in soil types and the soil fertility.

The low coastal plains, including the banks of the main rivers, have rather young soils that are rich in clay and silt particles. This means that these soils can retain and exchange nutrients quite easily; they have a reasonable high Cation Exchange Capacity (CEC) (See Box 1 on soil fertility and acidity).

The soils of the hinterland, however, are for a large part dominated by white and brown sands, red loam and inundated peat soils. Apart from the so-called mountain foot soils of the Upper-Mazaruni region, it can be said that the soils of the hinterland regions are acid and poor in nutrients, which is a major constraint for the type of agriculture found in the low coastal plains. The absence of young (non-weathered) clay and silt minerals results in an extremely low CEC of the mineral part of the soil. The fertility therefore depends almost completely on the organic matter in the soil.

Under forest cover, the content of organic matter (mainly colorless and thus invisible) in the top soil may be as high as 3%-5% (Sanchez et al, 1976) which may be enough to practice agriculture. However, once the protective forest cover is removed, and the soil gets exposed to the sun and direct impact of rain drops, the organic matter content of the soil decreases rapidly which makes farming impossible.

The original inhabitants of Guyana, the Amerindians, faced these same problems and without present resources like fertilizers, found a way of farming that they have practiced for thousands of years: shifting cultivation or slash and burn. Shifting cultivation is a cyclic process; this means that it starts again after a certain amount of time. The process is as follows: A piece of forest is cut, with exception of certain useful (fruit) trees, and burnt. A first crop of mainly corn and cassava is planted in the ash together with other miscellaneous fruits and vegetables. After two or three years, when weeds start to become a nuisance and the soil becomes too poor to yield good crops, the plot is more or less abandoned (depending on the presence of permanent crops). After 20 to 40 years, the forest vegetation has restored the soil fertility sufficiently to start all over again. Every year a new plot is cut and planted thus ensuring a continuous flow of food stuffs.

The whole process may seem primitive and devastating for the forest, but this is not the case. In a sufficiently large area with low population pressure these slash and burn practices offer an intelligent and sustainable solution to overcome environmental constraints.

Soil fertility is generally described by a number; the CEC which stands for *Cation Exchange Capacity*. This is a measure of the ability of the soil to retain positively charged ions or cations (nutrients). The CEC depends on the presence and type of clays and on soil organic matter. A high effective cation exchange capacity is needed to retain most cations against leaching. Because of the presence of highly weathered clay minerals like kaolinite or sandy textures, many tropical soils commonly have low effective CEC values. In such soils, increasing the CEC becomes an important management goal, especially when these soils are acid.

Acidity is measured in pH. A very acid soil has a very low pH (2 or 3). A neutral soil has a pH of 7. An alkaline soil has a pH of above 7. Acidity in itself is not harmful for plants, except in extreme cases. The problems affecting plant growth on acid soils are largely due to the large amounts of aluminium, and in some soils iron and manganese, which come into solution under acid conditions and are highly toxic. Also the CEC of kaolinite (the most common clay mineral in the tropics) is lower under acid conditions than under more neutral circumstances. Also some essential nutrients like phosphorus tend to become "fixed" and thus unavailable for plant growth at a low pH.

So, two factors are very important for soils: the CEC that tells you how well a soil can hold nutrients and the pH that gives an indication of the effectiveness of the CEC and the availability of certain nutrients. It is important to maintain a high CEC. This can be accomplished by two processes: adding limestone, shells or wood ash to acid soils and increasing soil organic matter content (Sanchez et al, 1976). Limestone reduces the acidity (which is good) but it also increases the speed with which the organic matter in the soil is decomposed. While it may also be difficult to obtain limestone, or shells, there are always ways to increase the organic matter in your soil.

Box 1: Soil fertility and acidity.

However, in Guyana of today, where many Amerindians have developed a more sedentary lifestyle and the forest resources are not as infinite as they seemed (due to gigantic timber and mining concessions), shifting cultivation is becoming an unsustainable way of farming. In fact, many Amerindians now have more permanent farms where sustaining good yields is often problematic.

During the WORKSHOP ON ALTERNATIVE LAND UTILIZATION TECHNIQUES FOR FOREST DWELLING COMMUNITIES organized by IICA and FUTURES FUND in Mainstay 23-29 April 1995, farmers and extension workers were asked to make an inventory of the most pressing problems for farmers in the hinterland.

These problems can be divided into three categories:

- A. **Infrastructure:** Inadequate education and poor marketing facilities were identified as the biggest constraints; due to the lack of (cheap) transport farmers often cannot market their produce. Also it is virtually impossible to obtain inputs from the coastal areas at an affordable cost.
- B. **Social:** Farming is not very popular among the children of many farmers; they would rather work in mining or timber and/or marry someone from the coastal areas. This endangers the continuity of the communities and the farms and the social stability.
- C. **Technical/Environmental:** Poor soils with a low CEC, largely due to a low content of organic matter. This results in poor yields and a high risk of the farms being unsustainable. Climatic factors such as wind and sun were also reported to reduce yields.

The soil related problems (C.) may be solved by technical means. To increase and/or maintain crop yields it is necessary to at least maintain and, if possible, increase the organic matter content of the soil. Also the soil needs to be protected against too much direct exposure to the sun and the rain in order to prevent erosion. Incorporating trees in the agricultural production process may make this possible. One means of incorporating trees in a production system is through Agroforestry.

This book gives practical guidelines on agroforestry, for farmers and agricultural extension workers. The book is divided into four parts:

Part one gives an introduction to Agroforestry and a concise theoretical background.

Part two describes various tree propagation techniques, including the set-up of a farm nursery. Also different tree management activities for Agroforestry are being dealt with.

Part three provides general information on the benefits and potentials of the most relevant Agroforestry practices for Guyana, and gives guidelines for implementation.

Part four describes those tree species, mentioned in part three, that are not indigenous to Guyana.

DEFINITION AND BASIC CONCEPTS

DEFINITION OF AGROFORESTRY

The International Centre for Research on Agroforestry (ICRAF) suggests the following definition:

Agroforestry is a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management units as agricultural crops and/or animals, either in some form of spatial arrangement or in temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different tree and non-tree components (Lundgren and Raintree, 1982).

According to Nair (1993), this definition implies that:

- Agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is a woody perennial.
- An agroforestry system always has two or more outputs.
- The cycle of an agroforestry system is always more than one year.
- Even the simplest agroforestry system is more complex, ecologically and economically, than a mono-cropping system.

Furthermore, if we read this definition carefully, we find that the trees and the crops and/or animals do not have to be grown together, but possibly one following the other. Shifting cultivation, therefore, is an agroforestry system where very cleverly, the fallow period (the regeneration of the natural vegetation) is used to accumulate nutrients for the following agricultural production cycle.

Other examples of agroforestry practices are windbreaks or shelterbelts, intercropping, improved fallow, alley cropping, coffee or cocoa with shade trees, living fences, trees with pasture, and many more. These will be described in chapter three. See also Box 2 for an example of an agroforestry practice used in Guyana.

FRUIT ORCHARD WITH PASTURE, a case study from Mabaruma, Region 1, Guyana.

Mabaruma is located on a small hill with a red clay soil. The particular farm is about 50 acres and includes slopes of different angles.

Mr. Chan-A-Sue started the planting of the orchard in the 1930's. He bought the plants from the nursery that was located at the agricultural extension centre in Hosororo. The main part of the orchard is planted with citrus trees of all kinds: lime, lemon, orange, tangerine, grapefruit and shaddock. These are planted in rows with a spacing of 25 x 25 ft.

Other parts of the farm are planted with tree crops such as coffee, avocado, carambola and different palm species.

Grass is used as a ground cover, on which cows, sheep and goats graze. Furthermore, pigs and chickens are reared. Additional fodder is obtained from the fruit trees. When they are pruned once a year, the prunings are fed to the animals.

The three different components, trees, grasses and animals, influence each other in different ways and provide different products and services. Besides fruits, coffee, palm oil and other products, the trees provide shade and fodder for the animals, organic matter and nutrients in the soil and protection from the soil against erosion. Effective protection against erosion is also provided by the permanent soil cover of grasses. The undergrowth layer also contributes organic matter to the soil and of course the main fodder supply for the animals. The animals provide milk and meat and their manure is a natural fertilizer.

Even now, after 60 years, the trees are still producing, although they are declining and the crowns do not touch each other any more. The main problem faced now is to obtain new plants to replace the old ones and to protect them in the early stages against the animals.

Box 2: Example of an agroforestry practice in Mabaruma, Region 1, Guyana.

Trees and crops can complement each other in terms of:

- **function:** the tree component in the agroforestry system primarily enhances and sustains agricultural production by improving microclimates and/or improving soil structure and fertility. Furthermore, it can provide other products and services such as fire wood, fruit, fodder, stakes, timber, useful chemicals such as medicines and pesticides, and others.
- **space:** roots of trees can penetrate into soil layers not used by annual crops; some trees can grow on places unsuitable for crops (stony, steep, acid or temporarily flooded land); in the process, the fertility of the soil may be improved.
- **time:** production and labour needs can be spread over several seasons.

EFFECTS OF TREES ON THE SOIL

Agroforestry practices are widely used to improve soil fertility and structure, to reduce the risk of erosion and to reduce extremes in microclimatic conditions. This is possible because of the physical and chemical properties of trees and the way these affect the surroundings of the trees.

We can distinguish the following beneficial effects that trees have on the soil (Nair, 1993).

A. Additions to the soil.

- **Maintenance or increase of organic matter** in the soil, mainly through decaying dead roots and decomposed leaf litter (see Box 3: Importance of organic matter in the soil).
- **Nitrogen fixation.** Nitrogen Fixing Trees are able to fix nitrogen from the air and change it into a nitrogen complex that can be used by plants. This nitrogen becomes available for the agricultural crops through the nutrient cycle (see Box 4: The nutrient cycle).
- **Nutrient uptake from deeper soil layers;** this is probable but has not been proven.
- **Atmospheric deposition;** trees reduce wind speed considerably and thus provide favourable conditions for dust (which contains a lot of nutrients) to be deposited. Furthermore, dust is collected in the canopy and will wash out to the soil during rain.

Organic matter is very important for the soil:

- First of all, organic matter provides nutrients for the plants. It is food for the plants.
- Second, organic matter has the ability to retain water. It works like a sponge: it keeps the water inside the soil. Organic matter is especially important, in sandy soils.
- Third, organic matter keeps the inorganic soil particles (like the sand grains) together. It is a sort of glue. Through this action, the soil particles cannot be washed away so easily when it is raining.
- Fourth, organic matter makes the soil feel very soft and makes it easier for the farmer to plough it. The soil is made friable.
- Fifth, organic matter can keep the other nutrients inside the soil. It can bind the other nutrients onto its surface so that these nutrients will not be washed away to deeper layers of the soil or into creeks or rivers, where the plant roots cannot reach them. We also call this the 'buffer capacity' of the soil or the cation exchange capacity (CEC). Clay particles also have this ability to keep nutrients together. Sand grains, on the other hand, bind very few nutrients to their surfaces. Sand therefore has a very low buffer capacity.
- Organic matter increases the pore space of soils and hence the aeration capacity.

It should be clear from the above why **ORGANIC MATTER** is very important for the soil and for plant growth. The farmer should always make sure that there is enough organic matter in the soil. Often a soil with ample organic matter has a black or brown colour, which is easy to identify. Sometimes, however, organic matter can also be colourless, in which case it can only be detected by a soil test.

High temperatures and humidity break down the organic matter in the soil fast. Therefore a continuous supply of organic matter is indispensable for sustaining plant growth on otherwise poor soils.

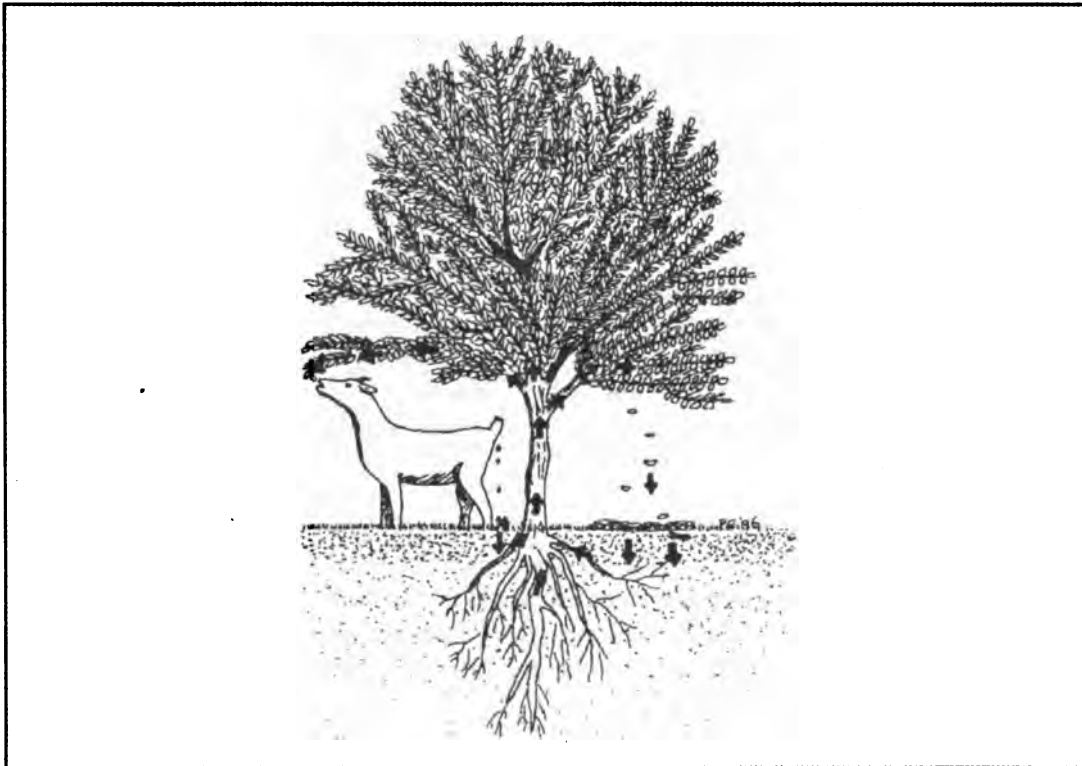
An example of this is demonstrated by the floor of a rainforest, where a thin layer of dead leaves can be found. These leaves are broken down very fast and the nutrients are immediately taken up by the trees and plants to enable them to grow. The layer of dead leaves of the forest floor gets replenished continuously by fallen leaves from the trees. This rapid recycling of the organic matter prevents it from forming a thick layer.

Box 3: Importance of organic matter in the soil.

The nutrients present ecosystems are mainly stored in, the leaves, twigs, bark and roots of the vegetation and in organic matter in the soil.

These nutrients can become available to plants through decomposition of the organic material in the soil.

Because of the limited amount of nutrients present and the small storage capacity of the soil, a continuous recycling of nutrients is important: **the nutrient cycle.**



Trees and plants take up nutrients from the soil to grow. When the trees drop their leaves, or when plants or trees die and fall on the floor they will decompose and the nutrients that come free can be used by other plants and trees.

When trees or crops are harvested it is important that the leaves and bark and the crop residues are put back into the soil to decompose so that their nutrients become available for other plants. When leaves and plants are used as fodder, the nutrients can be recycled by bringing the animal manure back on to the land.

Box 4: The nutrient cycle.

B. Reduction of losses from the soil.

- **Protection from erosion.** The impact from rain on the soil surface and the consequent erosion of soil particles is considerably reduced by protection from the canopy layer when this is lower than 30 ft. The tree root system and any increase of organic matter in the soil keep the soil particles together and prevent the particles from running off with rain water or being blown away by the wind. The litter layer and undergrowth on the soil surface assist further in the reduction of water and wind erosion.
- **Nutrient retrieval;** tree roots intercept and absorb nutrients that are leached out of the top soil and are out of reach of the roots of (annual) crops.

C. Effect on physical properties of the soil.

- **Maintenance or improvement of physical properties.** The enhancement of such properties as soil structure, porosity, moisture retention and erosion resistance under tree cover is well known, as is the decline of these properties without tree cover. The tree roots can penetrate compact and hard soil layers. This increases the porosity, thus improving the water holding and infiltration capacity, as well as the aeration of the soil.
- **Modification of extremes in soil temperature.** High soil temperatures have a negative effect on crop growth and (other) biological processes in the soil, for example the burning of organic matter in the top soil layer. Leaf litter cover and shade from trees help prevent extreme high temperatures.

D Effect on chemical properties of the soil.

- **Reduction of acidity.** The leaf litter of certain tree species (for example Neem) can help to reduce soil acidity.
- **Reduction of salinity or sodicity.** Afforestation has been used successfully to reclaim saline and alkaline soils.

Trees can also have some negative effects on the soil. Some of these are:

- E. **Nutrient competition** between trees and crops. Especially when the trees or shrubs have an established root system that dominates that of newly planted annual crops. Ideally, the rooting systems of trees in agroforestry systems should have deep penetration but limited lateral spread.

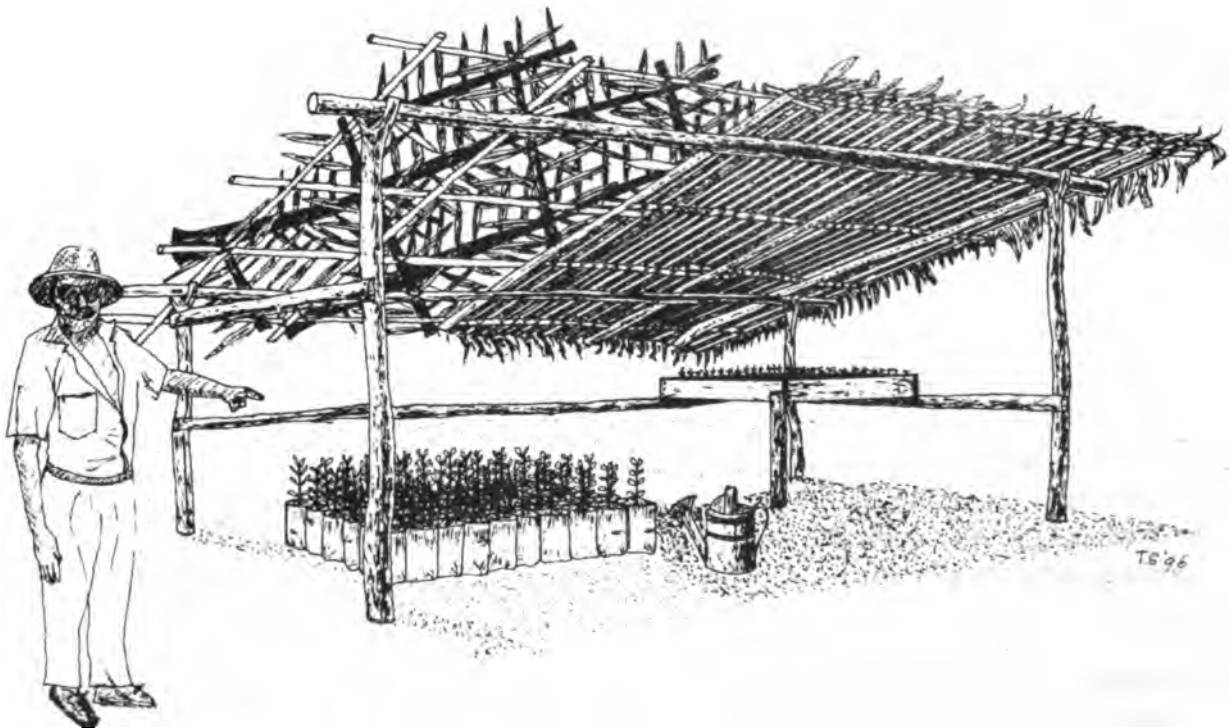
- F. **Moisture competition** between trees and crops. This is mainly a problem in the semi-arid zones, but also in physiologically dry environments like the white sands in Guyana.
- G. **Production of substances which inhibit germination or growth.** Some *Eucalyptus* species produce such toxins.
- H. **Loss of organic matter and nutrients in tree harvest.** The complete harvesting of fast growing species can lead to rapid depletion of soil resources. As long as leaves, twigs and bark are left to decay, this loss can be minimized. When the tree products are recycled directly (mulching) or indirectly (from fodder to dung), this is not a problem at all.

Of course all these beneficial and adverse effects do not always demonstrate themselves in the same way. Depending on the type of soil, the tree species, the crop type and the agroforestry system employed, some effects will be very important, while others may not even be detected. A careful choice of the agroforestry practice, tree and crop species used, and management practices applied, will aim for optimizing the positive effects and minimizing the negative effects.

CHAPTER TWO

TREE PROPAGATION AND MANAGEMENT

FOR AGROFORESTRY



TREE PROPAGATION

This chapter deals with the various methods of obtaining new planting material (trees) suitable for a farm. Most of them can also be applied on a smaller scale. The various methods are divided into two groups:

- A. Propagation through seed:
- planting seeds in a seed box
 - direct planting of seed in beds or bags
 - direct planting in the field
- B. Propagation through parts of the mother tree:
- stem cuttings
 - leafy cuttings

When planting certain tree species in an area for the first time, it is best to start with seedlings rather than with cuttings. If cuttings come from only one tree, they will have only one set of characteristics, like twins or like carbon copies of the mother tree. Seedlings, on the other hand, will all have different characteristics even if the seeds come from one tree; they are like different children from the same parent. Since they are all slightly different, some will be more resistant to certain pests or diseases, others may be able to cope better during a dry period, while still others may be more tolerant to flooding. This means that there is more scope for selection and a higher chance of survival when seedlings are used.

Once a certain tree species is well established in a specific area, cuttings can be taken from individual trees that have the desired characteristics. This is a cheap and fast method to preserve these characteristics.

PROPAGATION THROUGH SEED

Seeds may be obtained by purchasing them; however, if well developed mature trees of the species you want can be found close to your farm, you can collect the seeds yourself. One of the first things to consider is the selection of the mother tree. Choose a tree that has most of the desired characteristics you want in the young trees. Always use the best possible material for seed.

Collect at least twice as many seeds as you think you will need; this will make it possible for you to do some selection and serves as insurance in case of pests and diseases. (See Box 7 for an example on how to calculate the number of trees you need).

Seeds of some species can be collected by spreading out sheets or bags and shaking the tree. Others will drop their fruits out of which you can pick the seeds. Some species, however, force you to adopt more laborious methods to get their seeds. A good example is Neem. The seeds of this tree are so popular with birds that they are often eaten before they manage to drop. Other examples are those trees that have a pod that springs open suddenly or those trees whose seeds are dispersed by wind.

One way to overcome these problems is to make bags out of fine mosquito netting (of an old and torn net) and put them over the branches of the tree that carry fruit. This has to happen after flowering but before the seeds ripen and are eaten or disappear otherwise. With these bags in place, the birds cannot reach the seeds and, when ripe, the seeds will fall into the bag. It is best to use mosquito netting so that air, water and sunlight pass through while animals, like birds, are kept outside the bag. (see Figure 1).

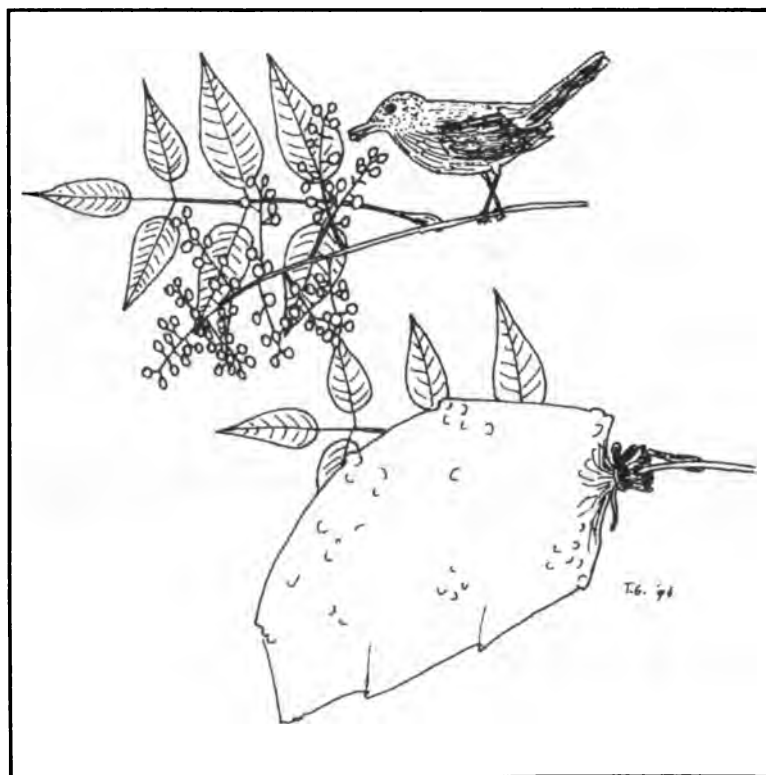


Figure 1: Seedbag to protect the seeds on the tree (upper branch not protected).

Care should be taken that seeds are not harvested green or too old. Generally it is good to clean the seeds and dry them for a few days in the shade - never in the full sun. After drying, the seeds should be stored in a cool, dry and dark place. It is best to use them as soon as possible, but sometimes this is not feasible because of the timetable in your nursery.

Sometimes the seeds will need a treatment (Box 5) before planting for one or more of the following reasons:

- to speed up the germination (bursting of the seed);
- to increase the number of seeds that germinate;
- to make sure that the seeds all burst at more or less the same time.

Generally such seed treatment aims at making the skin of the seed softer or thinner so that the seed can take up water and air more easily.

Hot water treatment:

- For every cup of seeds use 10 cups of water.
- Bring the water near boiling point, when the water starts to "sing".
- Take the water off the fire and let it cool down a little bit.
- Throw the seeds in the hot water and leave for about three minutes (or shorter if so mentioned in the tree descriptions).
- Put the seeds in a bucket of cold water and leave to soak for 24 hours.
- The seeds that are thick and swollen and are lying on the bottom of the bucket should be planted immediately. Seeds that are still thin and float around in the bucket can be left for another 24 hours. Again, plant those seeds that are swollen and have gone to the bottom of the bucket. Any seeds that stay thin and floating can be thrown away.

Cold water treatment:

- For every cup of seeds use 10 cups of water in a bucket.
- Place the seeds in cold water and leave them to soak for two days, while changing the water every 12 hours.
- Take out the seeds that are thick and swollen and that are lying on the bottom of the bucket. Plant these seeds immediately. Leave the seeds that are still thin and flat and/or float in the bucket of water for another 24 hours, still changing the water every 12 hours. The seeds that are swollen can be planted, the others thrown away.

Box 5: Two methods that are widely used for treatment of tree seeds.

There are many different kinds of treatment: from very simple ones like soaking overnight to more complicated methods that involve acids. The two most common methods are the hot water and the cold water treatment (see Box 5). The recommended treatment is mentioned in the tree descriptions in Chapter 4. If no method is mentioned, one can experiment to find an effective method. Some seeds require no treatment.

It is possible to plant the seeds directly in the field, directly in bags or beds or first in a seed box. You should decide which method to use long before you need to plant. Since it is always best to plant seedlings in the field at the beginning of the rainy season, you will need to grow the seedlings in a nursery during the dry season.

Using a seed box

A seed box (Figure 2) is a box about four inches (4") deep, with holes in the bottom. These holes should be big enough to drain off water but not so big that the soil washes away.

You should use a seed box:

- if the seeds are very small,
- if the seeds are very expensive or scarce,
- if you do not know how many seeds will burst (germinate), or
- if you know that less than eight out of ten seeds will germinate.

The box should be filled with either clean sand or a mixture of sand with a little compost (see Box 6 on soil mixtures). It does not need to be a rich soil mixture because the seed carries all the nutrients it needs to grow and survive for the first weeks. It is more important to have a clean soil mixture without fungi or insects that may damage the young seedlings.

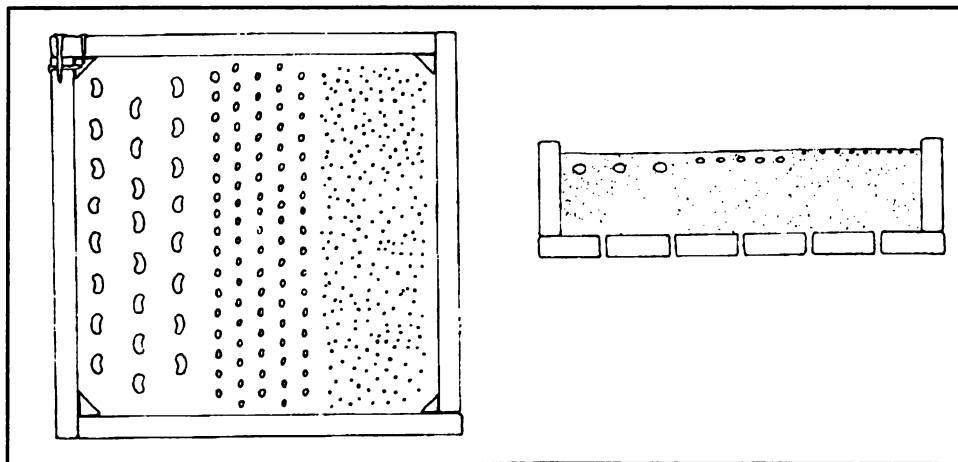


Figure 2: Spacing and depth of seeds in a seed box is related to the size of the seeds.

After having treated the seeds (if and when necessary according to the information you have on the tree species), you plant them in the box. As a rule of thumb, you plant the seeds as deep as their own diameter. This means that big seeds are planted deeper and small seeds are planted shallow. Very fine seeds are thrown on top of the soil and then pressed lightly with a piece of board. Generally, big seeds are planted in rows and small seeds are broadcasted (see Figure 2). You must water the seeds in the box and later the seedlings twice a day - in the morning and in the evening.

After some time, the seeds will start to burst and soon the seedlings will emerge. Often the seedlings will first have a pair of small, thick leaves. These are often not real leaves but rather the seedhalves that look and act like leaves. If everything goes well, the first real leaves will appear a few days later. When these are filled out completely, the time has come to transplant the seedlings (see Figure 3). If you plant the seedlings over too early, the plant is still very weak and will probably get damaged. If you wait too long with transplanting, the plants will get old, start fighting each other for water, nutrients and light and stop growing. Their roots also become entangled and this can cause serious damage if you try to pull the plants apart during transplanting. The seedlings can be transplanted to bags or to beds. Extremely fast growers (like *Acacia mangium*) can be transplanted directly to the field.

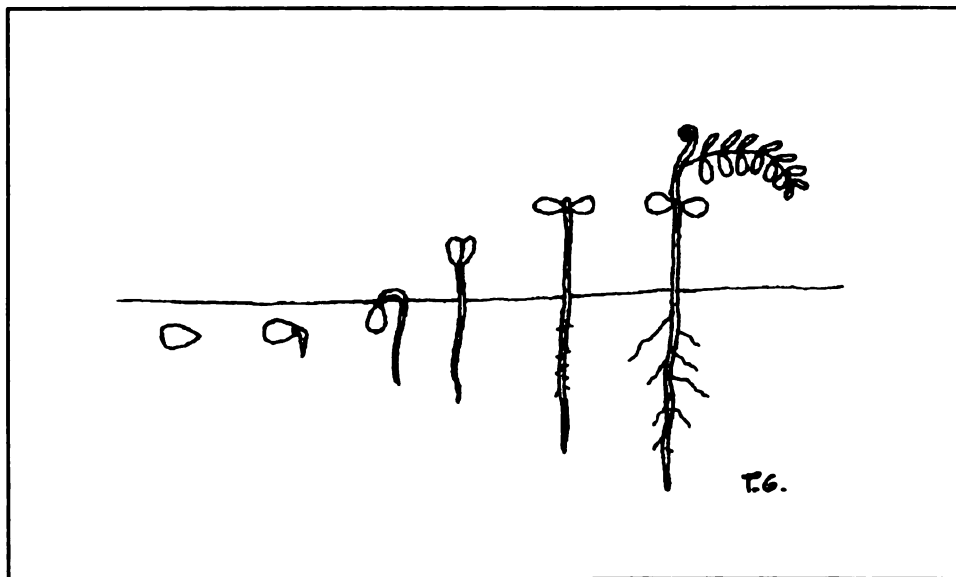


Figure 3: Germination and development of a seedling till the first real leaves.

If you take the seedlings out of the box, it is best to put one hand under the roots of the seedlings and lift them gently (see Figure 4). If it takes some time before you start transplanting, put them in a bucket of water. The best time of day to transplant is before 10 in the morning or, even better, after 3 o'clock in the afternoon. Then the seedlings will have the whole night to recover.

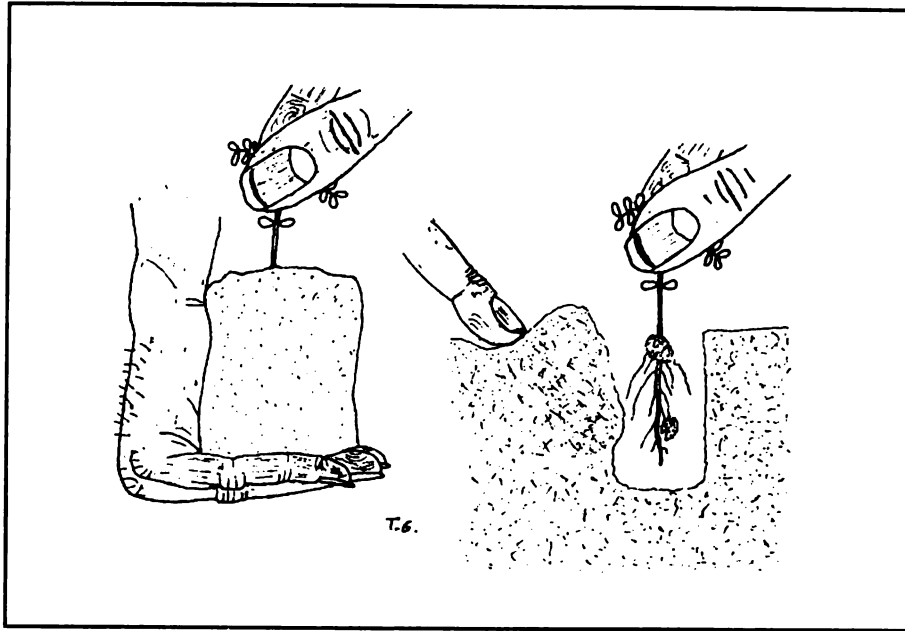


Figure 4: Transplanting of a seedling has to be done with care.

It is important that you have everything ready before you start transplanting. This means that if you want to transplant a thousand seedlings to bags, you must have a thousand bags filled with soil mixture before you start transplanting.

While transplanting, it is best to hold the seedling lightly between thumb and index finger; if you pinch it too hard, the seedling may die. You should take care that the roots are nicely stretched out in the hole and not curled up in one ball because then they will not grow (see Figure 4).

Planting seeds in bags or beds

This method is best to use if:

- the seed is cheap or easily available,
- a high percentage of seeds will burst,
- a known number of seeds will burst, or
- the seeds are too small to be planted directly in the field.

A better word for 'bag' would be 'container' because if you cannot get proper nursery bags, any type of container might be used; old cans, ordinary plastic bags, plastic bottles with the tops cut off or perhaps even cups made of bamboo or bags folded from trootie leaves. Any container will do as long as it has holes in the bottom to drain off water and is strong enough to last a few months until the seedlings reach plantable size.

A nursery bed is ideally 6 to 8 inches high and supported on the sides by boards, bricks, quartered banana stems or whatever is available. The bed should allow you to pass a cutlass underneath. The beds are normally between 3 and 4 feet wide and have enough space between them to walk and to place some tools or buckets.

The soil you use in the bags or beds should be free of sticks, roots and stones and have a good crumbly structure when moist (see Box 6).

The day before planting the seeds (or seedlings) in the bags or beds, the bags or beds should be given plenty of water. After planting, the bags or beds should be watered twice a day; in the early morning and in the evening.

In the beds, the seeds are placed in rows that are 4 to 6 inches apart. The spacing in the row depends on the size of seedling you want. Plant the seeds twice as deep as their own diameter.

From the information that is often provided when you buy seeds, or from a germination test (see paragraph 'planning of the production') you can obtain the germination rate. If you know that the number of seeds that will burst is lower than 8 out of 10 (80%) but higher than 4 or 5 out of 10 (40 or 50%), it is best to plant 2 seeds per bag. You can do the same in the beds (two seeds per place) or you can reduce the spacing in the row to 2 inches. If you get two seedlings in one spot, one should be weeded out. This is often better than trying to transplant it; transplanting might cause damage to the seedling that remains on the spot. The result is then two weak (or dead) seedlings instead of one healthy one. It might be best to provide some shade for the seedlings during the first few days. This can be done by building a simple frame and putting some coconut (or other palm) branches on top. These should be removed a week after the majority have germinated.

After some time, when the seedlings start to grow, it is necessary to prune the roots. This has to be done to prevent the roots of the seedlings from growing too deep or too wide and becoming entangled with other seedlings. Otherwise, this will cause severe damage when you want to take them out to plant them in the field. The roots of the seedlings in the beds can be pruned by passing a sharp cutlass horizontally under the bed at a depth of 6 to 8 inches and by cutting vertically in between the rows and in the rows in between the plants (see Figure 5). The roots of the seedlings in bags can be pruned by moving the bags over a small distance from time to time.

In this way, the seedlings will develop a strong and compact root system that enables them to expand rapidly once they are in the field.

Once the seedlings are big enough and when the conditions in the field are right (the rains must have started so that the soil is moist) the seedlings can be planted in the field. You should take care that you pick up the seedlings in bags by the bags; they should never be picked up by the stem.

A SOIL MIXTURE FOR BAGS AND BEDS

The soil you use for the bags or the beds is very important because the soil, together with the availability of water, determines the growth of your seedlings for the first few months.

If you want your trees to have a good start, the soil mixture should be:

- Not too clayey because it is very hard for the roots of young seedlings to grow and develop in hard clay because it does not drain quickly. A bit of clay is good because it helps to retain water and nutrients;
- Not too sandy because pure sand does not hold water very well. Some sand in the mixture is good because it drains easily and provides a loose structure;
- Rich in organic matter.

Organic matter has the following advantages:

- It improves the soil structure; it makes hard soils softer and binds loose, sandy soils;
- It helps to keep the soil moist;
- It is rich in nutrients that are released when the organic matter breaks down;
- It can bind nutrients from other sources (e.g. fertilizers) to its surface and release them when the plant needs them.

The ideal soil mixture has:

- one part clay or loam,
- two parts sand, and
- one part organic matter.

This organic matter should be well rotted; you should not be able to recognize what the source was. The best source would be compost. Compost is the dark brown or black soil that you get if you make a big pile of leaves, weeds, grasses, green twigs, kitchen waste, etc. and leave it to rot for half a year or a year.

Animal manure (for example from cows, donkeys or chickens) is also a valuable source of organic matter, but it should not be used when fresh. It is best used in combination with other organic material.

Pegasse (peat) could also be a valuable source of organic matter. However, pegasse is normally too acid (sour) to use directly. To reduce the acidity, you can mix the pegasse with sea shells, egg shells, limestone, or (wood) ash. You could also remove the pegasse from the swamp or savannah, pile it up and leave it to be washed out by the rains for half a year or a year.

Other sources are rice husk (well rotted), coconut dust, rotted coffee pulp, etc. If you want to use saw dust, you must leave it to be washed out by the rains for a year because many kinds of timber contain chemicals that could harm seedlings.

Box 6: A soil mixture for bags and beds.

When you uproot the plants from the beds, make sure that the roots are never exposed to the sun; keep them under a wet bag or at least in the shade. Take them to the field and plant them as soon as possible. The best time for planting is late afternoon.

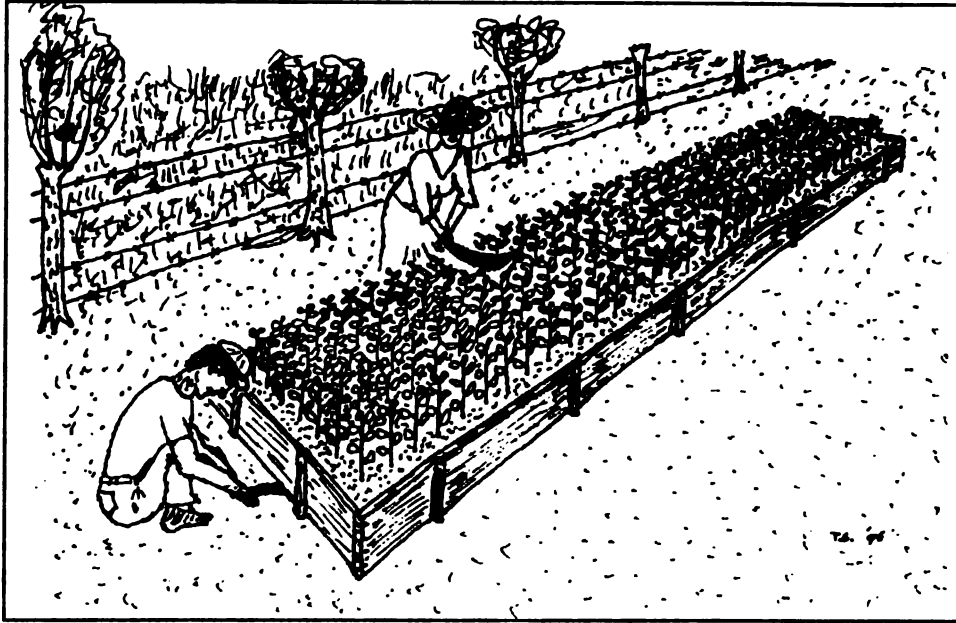


Figure 5: To prune the roots, cut with a sharp cutlass under and between the seedlings.

Planting seeds directly in the field

This is a good method to use if:

- the seeds are cheap and/or readily available,
- the seeds have proven to burst in high numbers, and
- the seeds are heavy enough not to be washed away by the rains.

Planting seeds directly in the field is mainly done when many trees are required. Transport of seedlings then causes difficulty. When planting seeds directly in the field, more seeds are required than when planting in a nursery to raise the same amount of trees. A good supply of seeds should be available. Direct seeding is better done with large seeds, as small seeds are easily washed away by the rain. In the young seedling stage, the trees are very vulnerable and it is best to use species with a fast initial growth.

Direct planting of seeds in the field is done at the beginning of the rainy season. If the seeds of the tree you want to use need any pre-treatment, follow the instructions in Chapter Four, Tree Descriptions.

Planting depth is important. When the seeds are planted too deep, the seedlings may not reach the surface after germination and may die. When planted too shallow, the seeds may be washed away or may dry out. Plant the seeds at a depth of about twice the diameter of the seeds. Before planting, you make small planting holes or furrows at a depth twice the size of the seeds. Plant the seeds at the bottom of the hole or furrow and cover them with earth until the soil is level.

During a dry spell, extra watering may be necessary. Weeding is essential when using this method, especially in the early stages when the seedlings are very small and cannot compete with weeds.

PROPAGATION THROUGH CUTTINGS

A cutting is a section of a stem or branch which will make roots when planted in the soil (like cassava sticks). Propagating trees using this method has several advantages. The tree propagated from a cutting will be identical to the parent tree (from which you took the cutting). Therefore, it is possible to select a good tree with desirable characteristics and multiply this tree by taking cuttings. This applies to good characteristics like fast growth or the production of many fruits, but also to the "bad" characteristics like being very sensitive to certain pests and diseases. So, the selection of the right mother tree is very important.

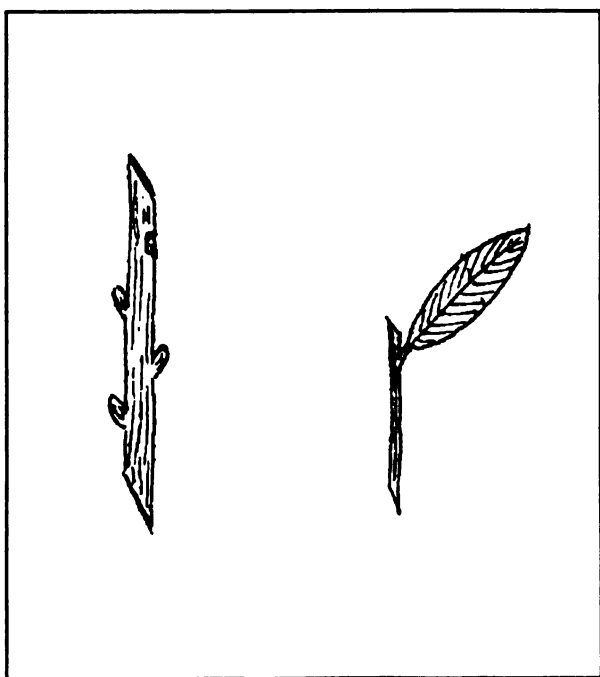


Figure 6: Example of a stem cutting (left) and a leafy cutting (right)

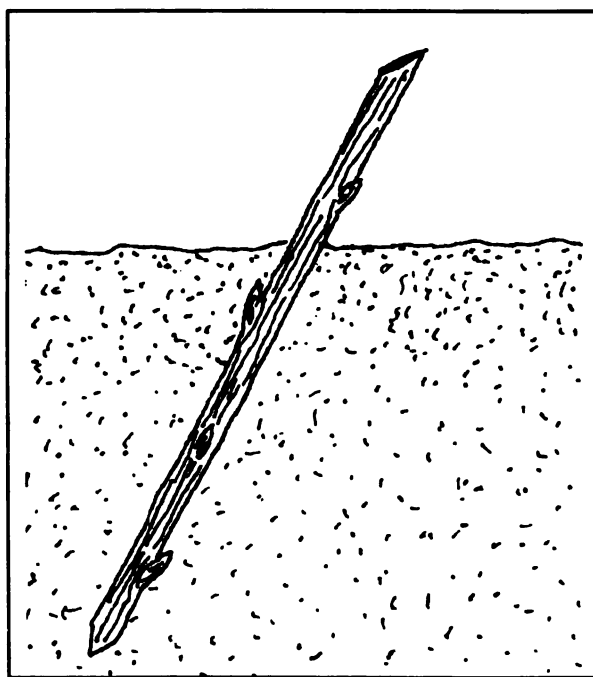


Figure 7: Plant a stem cutting slanted with the buds facing upwards and at least 2 buds in the soil.

Another advantage is that when stem cuttings are established, it immediately becomes a reasonable size tree, and the tree does not have to go through the vulnerable seedling stage.

Stem cuttings are cuttings made out of the woody branches and are one half to three in. thick and 8 in. to 7 ft. long. Leafy cuttings are cuttings from the top end of vertical branches; that part of the branch that is already firm and starts to become (or just is) woody (see figure 6). For both stem cuttings and leafy cuttings, the same type of branch is used. Always look for a vertical growing branch that is quite young. Never use hanging branches. The best type of branch to use is the type that appears first after a tree has been coppiced or pollarded. The woody parts of the stem, at the base, are used to make stem cuttings. The upper part of the branch, which is too young to be used as a stem cutting, may be used for taking leafy cuttings.

Stem cuttings

Stem cuttings are normally planted directly in the field. Long cuttings are mostly used when you establish, for example, a living fence and when it is important to have tall trees in a short period. For the establishment of the rows in an alley cropping practice, it is more efficient to use smaller cuttings. Most species grow best from cuttings that are 1/2 to 1 inch thick and between 1 and 2 ft. long.

It is best to plant the cuttings directly after collection to prevent them from drying out. If this is not possible, place the cuttings in a bag, keeping them moist and in a cool place (shade).

Prepare the planting site by loosening the soil and if necessary, and available, add some manure or compost. Cut the cuttings at the required length with a sharp knife at a slight angle and at the base in a blunt point (two slanted sides). Plant the cuttings in the soil at a slightly slanting angle. About two-thirds of the length, which must have at least two buds, are planted under the soil surface (see Figure 7). **Make sure the buds face upwards.** Sticks that are planted upside down will not grow.

Keep the planting site moist and free of weeds and animals at least until the cuttings are well established.

Leafy cuttings

Cuttings are taken by cutting with a razor sharp (stainless steel) knife as indicated in Figure 8. You cut off all the leaves from the cutting, without damaging the buds, except for the topmost leaf. If that leaf is small, you can leave it intact; if it is big, you can cut off part of the leaf so that the remaining part is about one square inch in size. The cuttings are planted in a propagator (Figure 9) which is placed in the (half) shade.

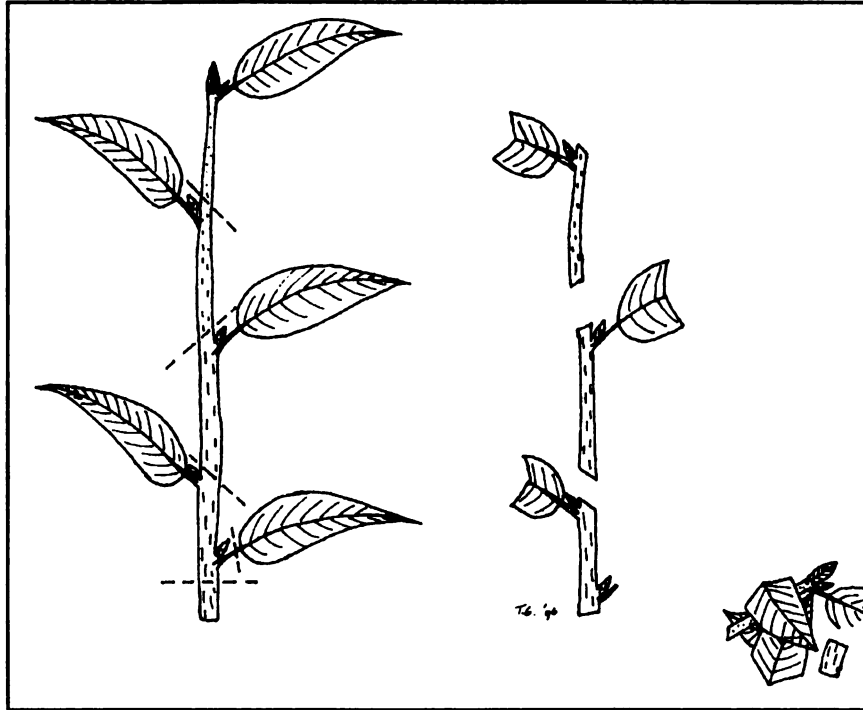
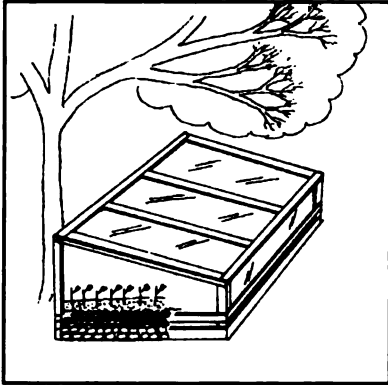


Figure 8: To take leafy cuttings, cut as indicated with the dotted lines. Big leaves can be cut to size.

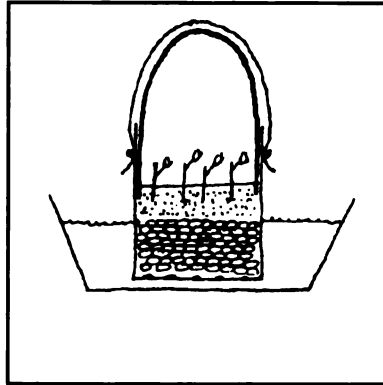
A professional propagating unit consists of a wooden frame enclosed with clear plastic (at the bottom very thick and strong plastic) or a concrete box with a glass top. At the bottom of the propagator (on top of plastic), you first put a layer of stones, on top of that a layer of fine gravel, and the top layer consists of a mixture of sand and organic matter. The box is filled with water up to the border between the sand and gravel (see Figure 9a).

The principle of the propagator is that the air inside stays very humid, so as to prevent the cuttings from drying out during the time that they grow roots and new leaves. Topping up the water level to the mentioned border is therefore very important.

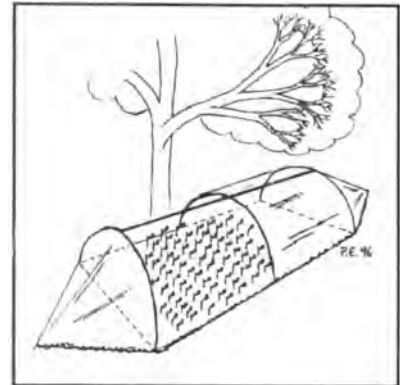
You can improvise a small-scale propagator by taking a large can, punching holes in the bottom and filling it with a layer of crushed stones, and on top of that, the sand mixture. Bend some hoops out of a pointer broom or comparable material (strips of bamboo, mukru, young twigs) and stick those in the can. Stick the cuttings in the sand. Put a clear plastic bag over the hoops and tighten it around the can with a string or rubber band. Then place the can in a bowl with water so that the water level outside the can corresponds with the line between the crushed stones and the sand in the can (see Figure 9b).



9a: professional propagator



9b: can propagator



9c: bed propagator

Figure 9: Three types of propagators.

A larger variety might be made out of a half-drum. The drum will not fit in a bowl of water, but a small hole in the side of the drum (instead of the holes in the bottom) will ensure the correct water level.

If these materials are not available or you need to propagate a lot of cuttings, the following method is worth a try. Make a bed out of a loose sand mixture with some compost. Make hoops out of bamboo across the bed with one strip at the top along the bed. Plant the cuttings in the bed and give them plenty of water. Take a clear plastic sheet and place it over the hoops.

Dig it in on all sides so that there are no openings and no holes (see Figure 9c). A disadvantage of this method is that you will have to water the cuttings twice a day, because the water drains away in the soil. Watering is very cumbersome, because you will have to partly remove the plastic and dig it in again after watering. Maintaining the shade is even more important with this method.

Many technical books claim that you should treat leafy cuttings always with a rooting hormone powder, but for many of the species discussed here, that is not necessary.

You will know that your cuttings have started to form roots as soon as you see they are making new leaves. As soon as the first few leaves are filled out, it is time for the cuttings to start hardening off. This means that the cuttings have to gradually become accustomed to the environment outside the propagator. If you take them out at once, they will probably all die. You will have to give them time to adapt by opening up the propagator for half an hour per day. Every day you open up the propagator a bit longer, checking whether they stand erect. If they all go limp, it is time to close the propagator, after watering it first. As soon as you can leave the propagator open for a major part of the day, it is time to transplant the cuttings. From then on you can treat them like seedlings.

PLANTING AND PROTECTION OF SEEDLINGS

Once the seedlings or (leafy) cuttings you have raised in the nursery (nursery stock) are about 1 ft. high, they can be transplanted into the field. There the young trees need care and protection.

Planting of nursery stock

Planting of nursery stock is done at the beginning of the rainy season (when the soil is moist up to a depth of at least 8 inches) and preferably on a cool and cloudy day. Land preparation for the planting can be done some time before. The planting site needs to be cleared of weeds and planting holes of at least 1 ft. wide and 1 ft. deep must be dug. Mix some manure and/or compost with the soil coming out of the hole.

When the nursery stock is grown in bags, remove the bags just before planting. This is done by cutting the bag open lengthwise, after which it can be removed easily. Place the seedlings (or cuttings) in the hole and fill it up with the soil mixed with manure and/or compost. Pack the soil firmly around the roots, so that no air pockets are formed in the soil. Plant the seedlings at such a depth that when the planting hole is filled, the seedling is as deep in the soil as it was in the nursery (see Figure 10).

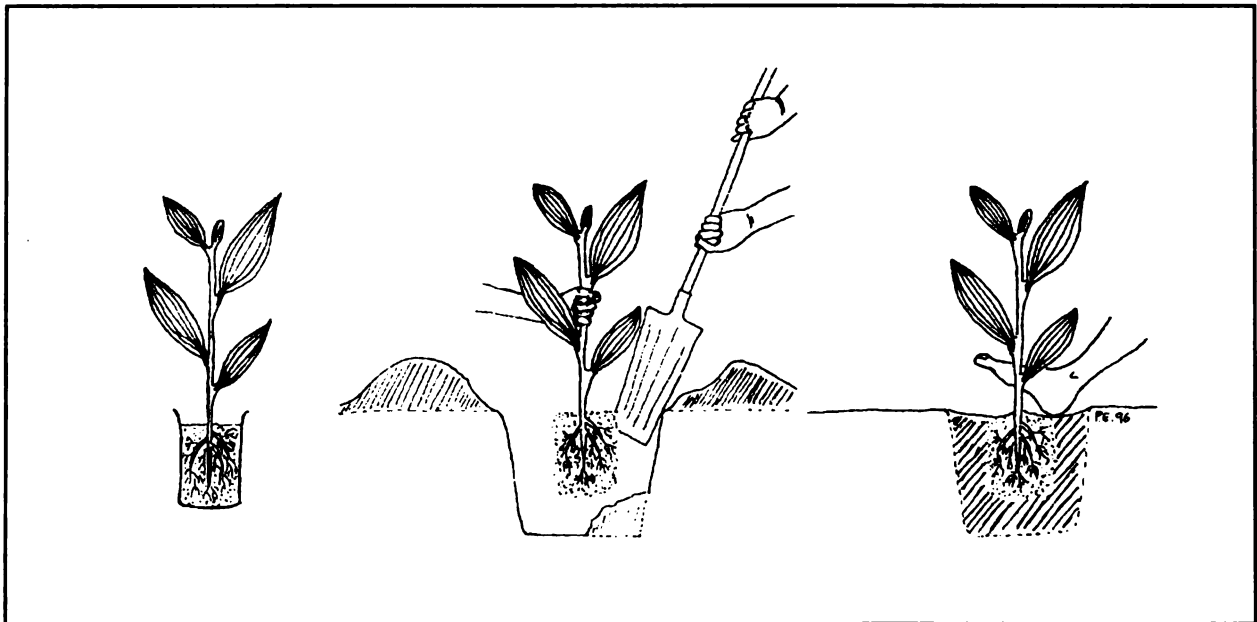


Figure 10: Planting of a seedling: remove the bag from the seedling, plant the seedling in a large hole and press lightly with your foot.

If there is no rain, water the newly planted trees. Place a layer of mulch around the stem. This will reduce evaporation and lessen the growth of weeds. Add some Neem leaves to the mulch to keep termites away. Water the seedlings regularly when there is no rain; keep the area directly around the seedlings free of weeds and protect the seedlings against animals.

Protection

All young trees need to be protected against animals. This is especially so for legumes, which are often very attractive to cattle. If it is not possible to keep the animals completely out of the planted area, the individual trees need to be protected. Some different methods (Figure 11) of protection are:

- planting thorny branches around the young tree;
- planting six to seven sticks straight in the soil around the tree and weaving a kind of open basket, using flexible material like bamboo or muku; or
- planting three to four sticks straight in the soil and nailing wooden sticks on them from the top to the bottom.

Protect the trees until they are tall and established enough to withstand the browsing animals.

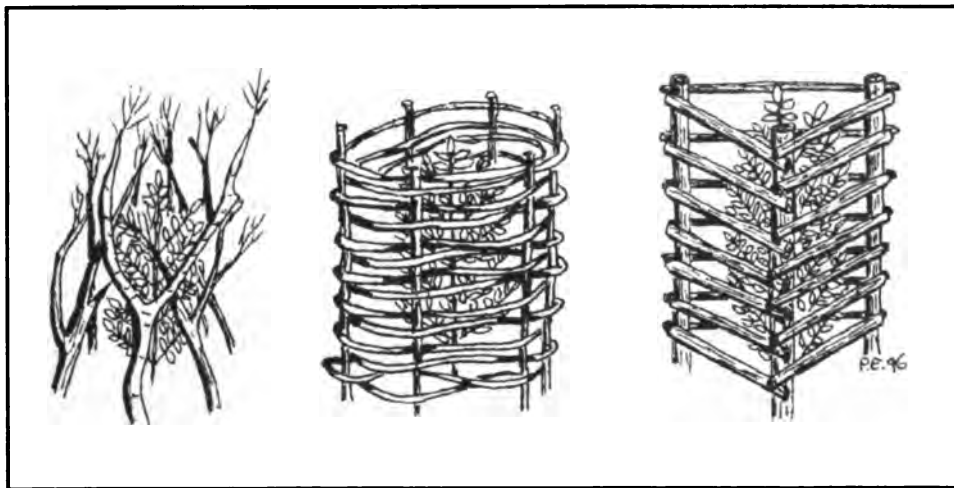


Figure 11: Three ways to protect seedlings against animals.

A FARM NURSERY

Location

Perhaps the most important factor in choosing the location for a nursery is the presence of a reliable source of clean water. Since you want to plant your seedlings and cuttings at the beginning of the rainy season, the majority of the activities in the nursery take place during the dry season. Most plants in the nursery need to be watered twice a day, so daily you will need a lot of water during the dry season. It is therefore wiser to build your nursery, if necessary, a little distance away from your farm if that location ensures a constant water supply; it is better to carry the seedlings over that distance once, than to carry water over that distance twice a day. Of course, your nursery should not be too far away from your house, because it needs daily care.

The terrain on which you build your nursery should be as level as possible and well drained. The area should not flood either, at least not while you are raising your seedlings and cuttings.

It is good if part of the nursery is shaded lightly under trees; most of it must, however, receive full sunlight.

Features of a farm nursery

How your nursery should look depends on a lot of things:

- the number of trees you want to produce;
- which species you want to produce;
- the propagation method you want to employ;
- the resources you have available.

A typical farm nursery could include the following:

- A nursery shed with one side fully thatched with troolie or ite palm leaves to create a fully shaded environment and one side half thatched with coconut branches to create a half-shaded environment (see Figure 12). In the half-shaded area you can place the propagator and the seed box. In the fully shaded area you place recently transplanted seedlings for a few days, after which they will be placed in the half-shaded area and then in the full sun.
- Beds to produce bare root trees. This should be in the full sun, but have the possibility to establish some half shade when necessary.

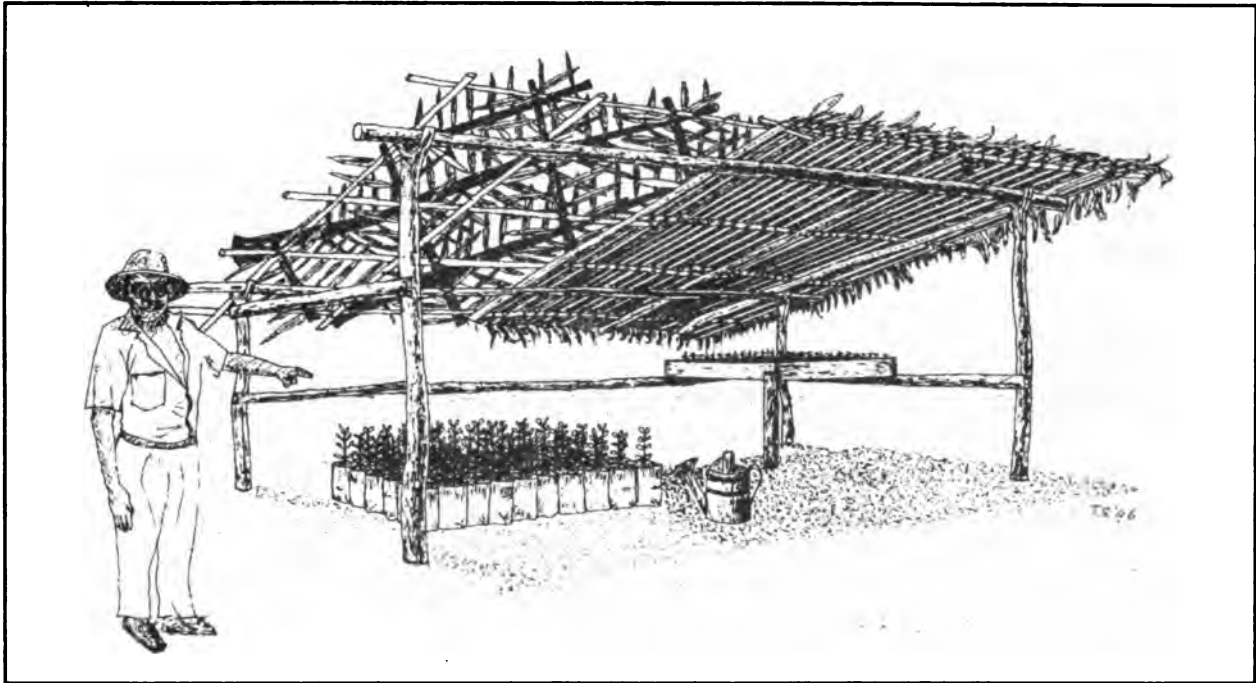


Figure 12: A farm nursery, with half shade and full shade area. Note the seedbox and the seedlings in bags.

- An area to put bags with seedlings. This should be in the full sun, but allow for the possibility to establish some half shade when necessary.
- A compost heap. This can be an open box (air must be able to enter) where all kinds of organic material are piled up: weeds, leaves, twigs, grass, manure, cassava peel and others. These are left to rot for about a year. It is best to have two compost heaps. While you use last year's, you build this year's compost heap.

Planning of the production

The nursery is supposed to produce an adequate number of healthy trees over time. The number of trees is something that you can never guarantee beforehand, but there are ways to make sure you produce the number of trees you need.

If you have a fixed amount of seeds, it is good to do a germination test beforehand, to determine how many seeds you need to plant to get the required amount of trees and to be sure you have enough seeds. The amount of seeds to use in the test depends on the amount of trees you want. If you want one thousand trees, you can take a sample of one hundred seeds; if you want one hundred trees, you can take a sample of ten seeds; if you want only ten trees there is no need for a test.

The test sample must be given the same treatment as the rest. If you plan to give your production seeds a hot water treatment, it makes no sense to give your test sample a cold water treatment. If no recommendation is given on which treatment to use for the tree species you want to grow, you can take two samples and give one a hot water treatment and the other a cold water treatment and see which one gives the better results. Plant the seeds in a seed box and wait until no more seedlings appear and count how many there are. To calculate the germination rate of the seed sample, you divide the number of seedlings you counted by the number of seeds you planted.

To calculate the minimum number of seeds you will have to plant, you divide the number of trees you want to grow by the germination rate. It is best to plant some extra seeds, as this gives you some insurance in case of pests or diseases and also gives you some room for selection.

Timing of the activities in the nursery is very important. Seeds must be planted on a timely basis and all preparations must be ready when the seedlings need to be transplanted into the bags or beds. This means that you will have to arrange all the inputs (bags or other containers, the various components for the soil mixture, the propagator, and others) and ensure that the bags are filled or beds prepared. See also Box 7 for an example of the planning of the production.

Pest and diseases in the nursery

Apart from obvious threats like seed-eating birds and rodents, there are two major production constraints in the nursery.

The first one is the so-called 'damping-off'. This is a fungal disease that attacks very young seedlings in the seed box. When infected, the plants fall down and it looks as if their stem has melted just above the ground. Needless to say, those plants will die. This disease can be avoided by regularly changing the sand in the seed box. Ideally, every batch of seeds should be planted in fresh and clean sand. It is better if sand comes from a sand pit rather than from the top soil of your farm or the forest, because these latter soils contain a multitude of fungi and other pests.

The second constraint is the acoushi ant. It is terrible to see the damage that one nest of acoushi ants can do to a nursery overnight. All those young and juicy leaves must be very attractive to them, especially in the dry season. Efforts should be made to bait the acoushi nests around the nursery. A preventive measure can be to cover the posts of the nursery shed (which supports the frame for the seed box) with bands of axle grease, vaseline or similar substances. You may consider building boxes for the seedlings to keep them off the floor, and cover the legs of those boxes with the same substances.

PLANNING OF THE PRODUCTION OF TREES OF A ONE-ACRE ALLEY CROPPING PLOT.

Farmer William wants to establish a one-acre alley cropping plot of 15 x 25 rods using *Leucaena leucocephala*. He wants to plant the rows of trees one rod (12 ft.) apart, parallel to the longer side of the plot. He wants to keep the borders free, because he is planning to plant fruit trees there later. This way 14 rows of trees can be planted on the acre. He also wants to keep one rod free on both ends of the tree lines, so that it is possible for a tractor to work on the plot. This means that the tree lines will be 23 rod long.

He calculated that he would have to plant 14 rows of trees each 23 rods long. An extension worker told him that the trees should be planted 2 ft. apart. This means there are 6 trees per rod. William therefore needs $14 \times 23 \times 6 = 1923$ trees, let us say 2000 trees.

William's brother-in-law gave him a bag of seeds. William has read that about 7 out of 10 seeds are supposed to germinate, but since he does not know how old the seeds are, he decides to do a germination test. He takes 100 seeds, gives them a hot water treatment and plants them in a seed box. After about 2 weeks, 66 seedlings have emerged and it looks as though no others are going to appear.

William calculates the germination rate: $66 \div 100 = 0.66$.

Then he calculates how many seeds he will have to plant to get 2000 seedlings:

$$2000 \div 0.66 = 3030.$$

Since William has enough seeds and wants to be on the safe side, he decides to plant 3500 seeds. This will give him about $3500 \times 0.66 = 2310$ seedlings. He wants to have the seedlings ready by May 15 and he knows that they need about three months in the nursery. So he decides to start planting the seeds in the seed box on February 14.

Since the seedlings reach a transplantable size in 2-3 weeks, William wants to have the bags and beds ready by February 28. However, he only has 1200 bags. He also wants to keep a few bags for the fruit trees he is going to produce later. He will use 1000 bags now and plant the other seedlings (1310) in beds.

William still has some beds from last year that will only need some restoration and then some fertilizing with compost, ploughing and raking. The beds are 4 ft. wide and their total length is 30 ft. William wants to know whether this will be enough. He figures he can plant 11 rows lengthwise on a bed if the spacing between the rows is 4 inches (leaving 4 inches free on the sides of the bed). When planting the 1300 seedlings in the 11 rows, he will have to plant $1300 \div 11 = 118.2$ seedlings per row. The spacing of the seedlings within the rows he would like to keep is 4 inches as well. He calculates that he will need $118.2 \times 4 = 473$ inches (= 40 ft) of bed 4 ft. wide. So he will have to prepare another 10 ft. of bed.

Box 7: Example of production planning.

The bags have a volume of about 2 pints each. This means that the total volume of the soil mixture needed for the bags is $1000 \times 2 = 2000$ pints or 250 gallons.

William wants to make a soil mixture of 2 parts sand, 1 part loam and 1 part compost.

This means:

$250 \times 0.50 = 125$ gallons = 42 buckets of sand;

$250 \times 0.25 = 62.5$ gallons = 21 buckets of loam;

$250 \times 0.25 = 62.5$ gallons = 21 buckets of compost.

William thinks that he and one of his sons need two days to collect the materials, mix the soil and fill the bags, one day to make the new bed and two days to prepare the old beds. This is all finished before February 28 when the first two leaves of the seedlings are filled out and William can start transplanting.

The seedlings grow well. William makes sure he waters them twice a day and weeds the beds and bags regularly. The rains start to fall by the beginning of May, but William waits a little longer before planting until the soil is good and moist. In the meantime he has prepared the planting holes and by May 15, everything is ready to transplant the seedlings to the field.

When the whole plot is planted, William still has about 200 trees left. William's neighbour is very interested in them. He has some animals and could use some trees on his pasture land. William sells his extra trees to his neighbour and so also earns a little cash from all the work done on the production of the trees.

Box 7: Example of production planning, continued.

Production tips

- Do not plant the seeds too close together.
- Change the sand in the seed boxes regularly.
- Do not plant the seeds too deep. In the seed box, only as deep as the diameter of the seed; in bags or beds, twice the diameter.
- Transplant in time from the seed box to the bags or beds. The seedlings are ready to be transplanted when two real leaves are formed. Hold the seedlings by the leaves, never by the stem.

- Do not fertilize the seed box. The seeds contain all the nutrients the seedlings need for the first few weeks.
- Do not make the seed box too dark. The best place for the seed box is in the half shade. Be careful that there is no risk of damage by rain.
- Do not use fresh organic material in the bags or beds. Organic material first needs to decompose for about one year. Fresh organic material can carry pests and diseases and it does not fertilize. On the contrary, the bacteria that try to break it down draw nutrients from the environment (from the seedling).
- Do not produce nursery stock in bags (more expensive) if you can transplant into beds to produce bare root stock or if you can plant the seeds directly in the field (these are much cheaper methods).
- A nursery needs to be weeded regularly. If the weeds in the bags or beds become too big the seedlings will be damaged while pulling out the weeds.
- Do not water at midday, only in early morning and late afternoon.
- Do not water too much. When you see a green slime (algae) form on the soil, you are giving too much water.
- Check your timing. Plant the seeds at such a time that the trees are ready for planting at a convenient moment.
- Harden the seedlings off about two weeks before they are to be planted in the field. Start giving them less and less water so that they get used to a drier environment. The last day before planting, you give them a lot of water so that they can suck themselves full.

MANAGEMENT

Management of trees for agroforestry practices is mainly aimed at the production of biomass (for mulch, green manure and other forms of organic matter), to influence the micro climate, to minimize competition for water and nutrients with crops, and to produce the desired products. Different management activities for agroforestry are discussed here.

PRUNING

Pruning is the removal of the lower branches of the crown (Figure 13).

Pruning can be done to reduce shading of the adjacent crop, to improve the quality of the trunk when used for timber or poles, and to harvest branches for firewood, mulching, fodder and other uses.

When trees are grown with a crop, remove those branches that interfere with the crop until well above the crop. Cut the branches as close as possible to the trunk of the tree. Never cut too many branches; leave at least 4 to 5 layers of green branches on the tree.

Pruning is best done at the end of the dry season.

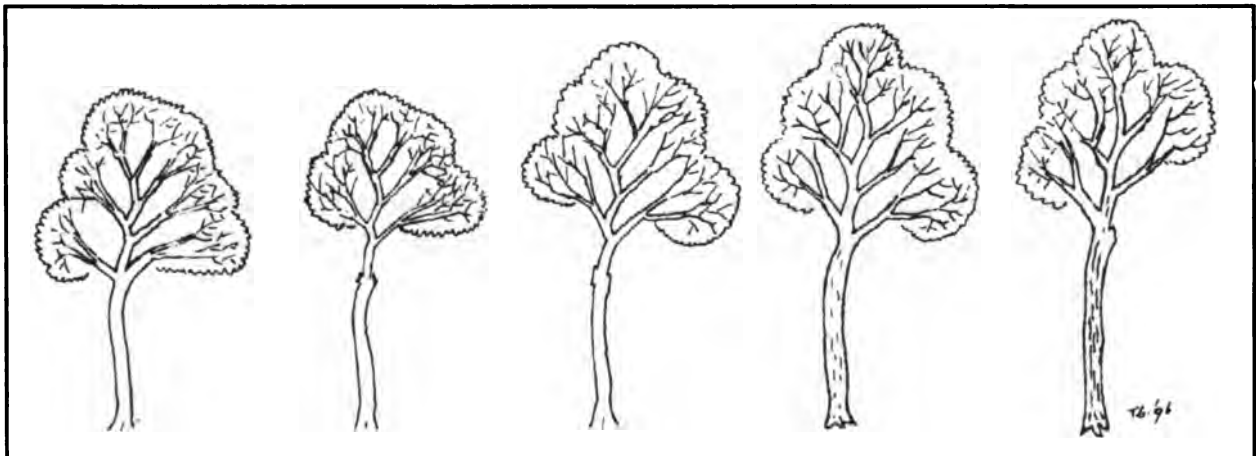


Figure 13: Pruning.

LOPPING

Lopping is the harvesting of branches or parts of branches in a more haphazard way (Figure 14).

The main reason for lopping is to collect fodder. Therefore, branches are selected with a good, green leafy biomass. Those branches can be cut off with a cutlass at any point, not necessarily close to the trunk. Branches can be cut from any part of the tree. However, do not take too many branches at a time.

Lopping can be done any time fodder is required.

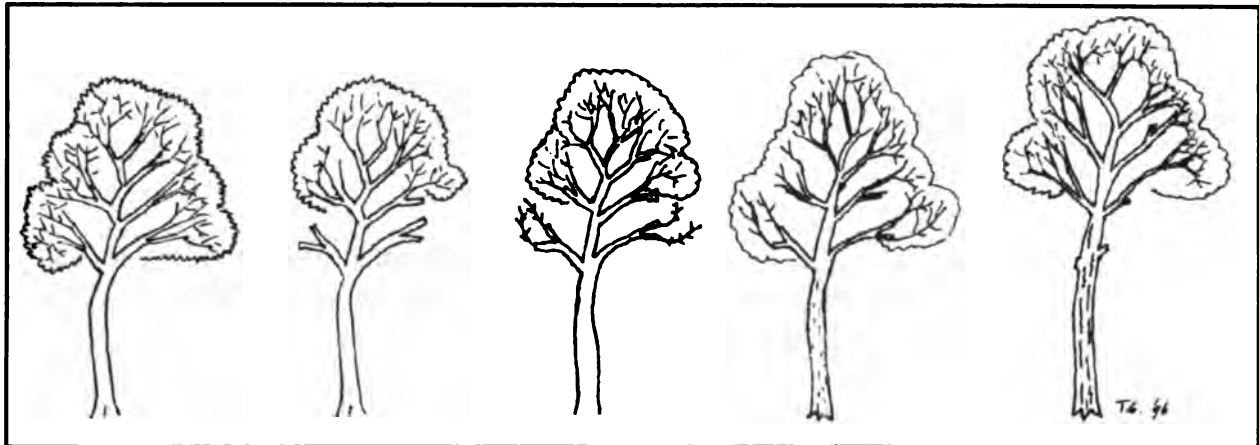


Figure 14: Lopping.

POLLARDING

Pollarding is the removal of all the branches and the top of the tree so that only the trunk is left, after which the tree will resprout (Figure 15).

Pollarding is done to harvest wood, fodder, mulch and other biomass and to reduce the shading of the adjacent crop. When the tree resprouts from the top of the stem, the branches will be out of reach of browsing cattle. The trunk can be left to grow for timber or poles.

When you want to use the trunk for timber or poles, you can cut the tree at a higher point, leaving a longer stem to grow. When pollarding is done to produce smaller wood, fodder, mulch and so on, you can cut the tree lower, making it easier to reach. Do not cut the branches at the top too close to the trunk, but let them stick out 1/2 - 1 ft. to form a wide base for the new crown to form. If the newly formed crown is too dense, some branches can be pruned.

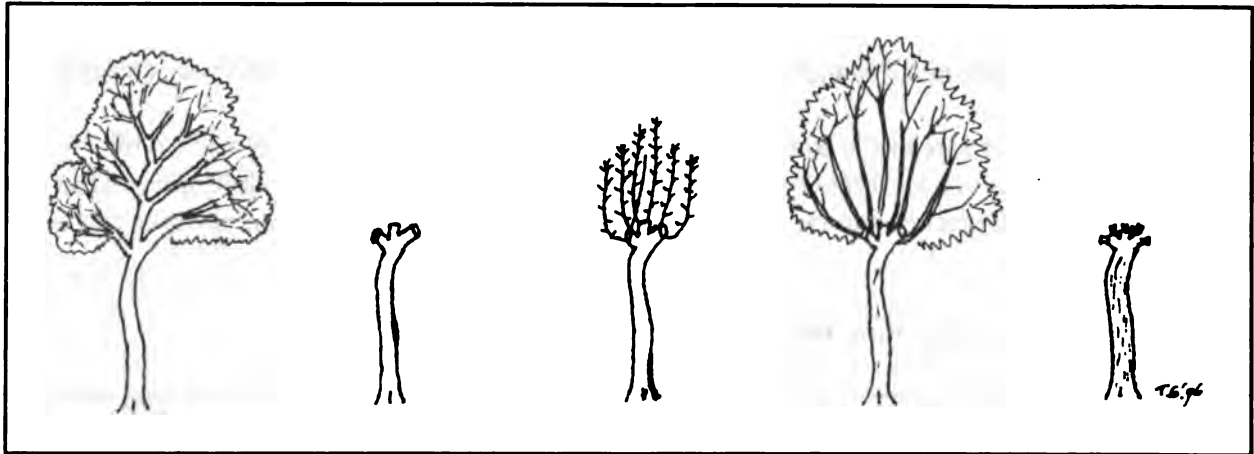


Figure 15: Pollarding.

Pollarding is done at the end of the dry season. When producing small wood, fodder and mulch, or when growing with crops, pollarding can be done once or twice a year. If bigger wood is required pollarding can be done every 2 to 5 years.

Not every tree species will resprout after pollarding and some do so only when they are young.

COPPICING

Coppicing is the harvesting of the complete tree at the base, after which the tree will resprout from the base (Figure 16).

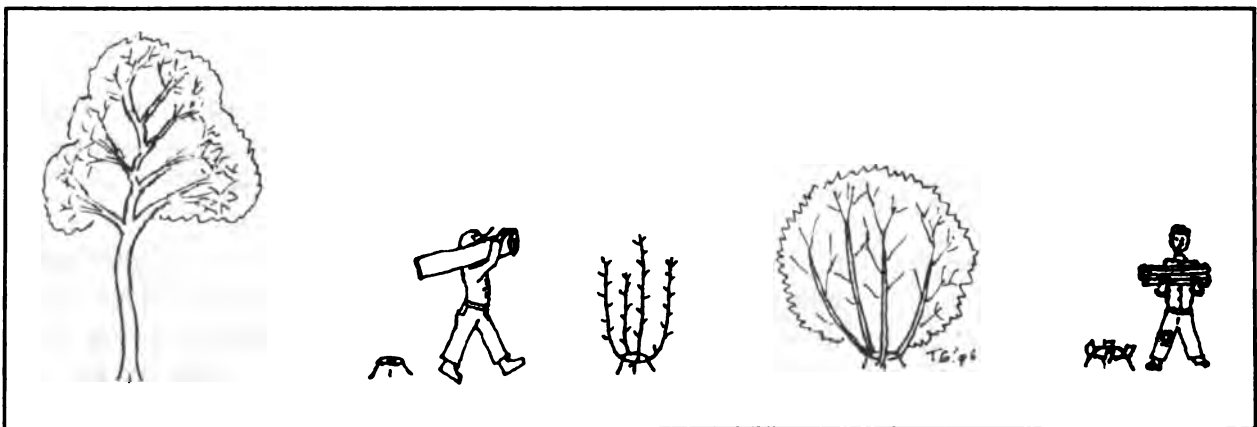


Figure 16: Coppicing.

Coppicing is done to harvest wood, fodder, mulch and other biomass and to reduce shade for the adjacent crops. Coppicing is applied especially in alley cropping for this reason. Some species are able to form a complete new tree from the base. In this case coppicing is used as a propagation method.

The tree is cut at a height of about one foot at the end of the dry season or beginning of the rainy season. Many new sprouts will grow out of the base. When mulch, fodder or small wood is required, the sprouts can be left to grow and be pruned when needed. When the intension is to produce a new tree, all sprouts are removed except for one that is going straight up. This one will form the new tree.

Coppicing can be done regularly for mulch and fodder. Depending on the tree species used and the crop with which it is grown, coppicing can be done 4 to 5 times a year (sometimes even more). If you want to produce a new tree, you only coppice when it is tall enough to be harvested. After harvesting 2 to 3 trees from the same trunk, you will need to replant the complete tree.

Not every tree species will resprout after coppicing and some onlydo so when they are young.

THINNING

Thinning is the removal of complete trees to open up a stand (Figure 17).

When it is necessary to create a closed stand in a short period (for example, to reduce the risk of soil erosion or for improved fallow practices), many trees are planted or sown close together. When the stand is getting too closed, the growth of the trees will be hampered (they will grow just as tall, but very thin and unstable) and some of the trees will need to be removed in order for the other trees to develop well. You can, for example, cut down every second or third tree. When the trees grow further, a second or third thinning may be necessary. The harvested wood can be used for poles, fuel or other uses. Leaves and bark can be left for mulch or used as fodder.

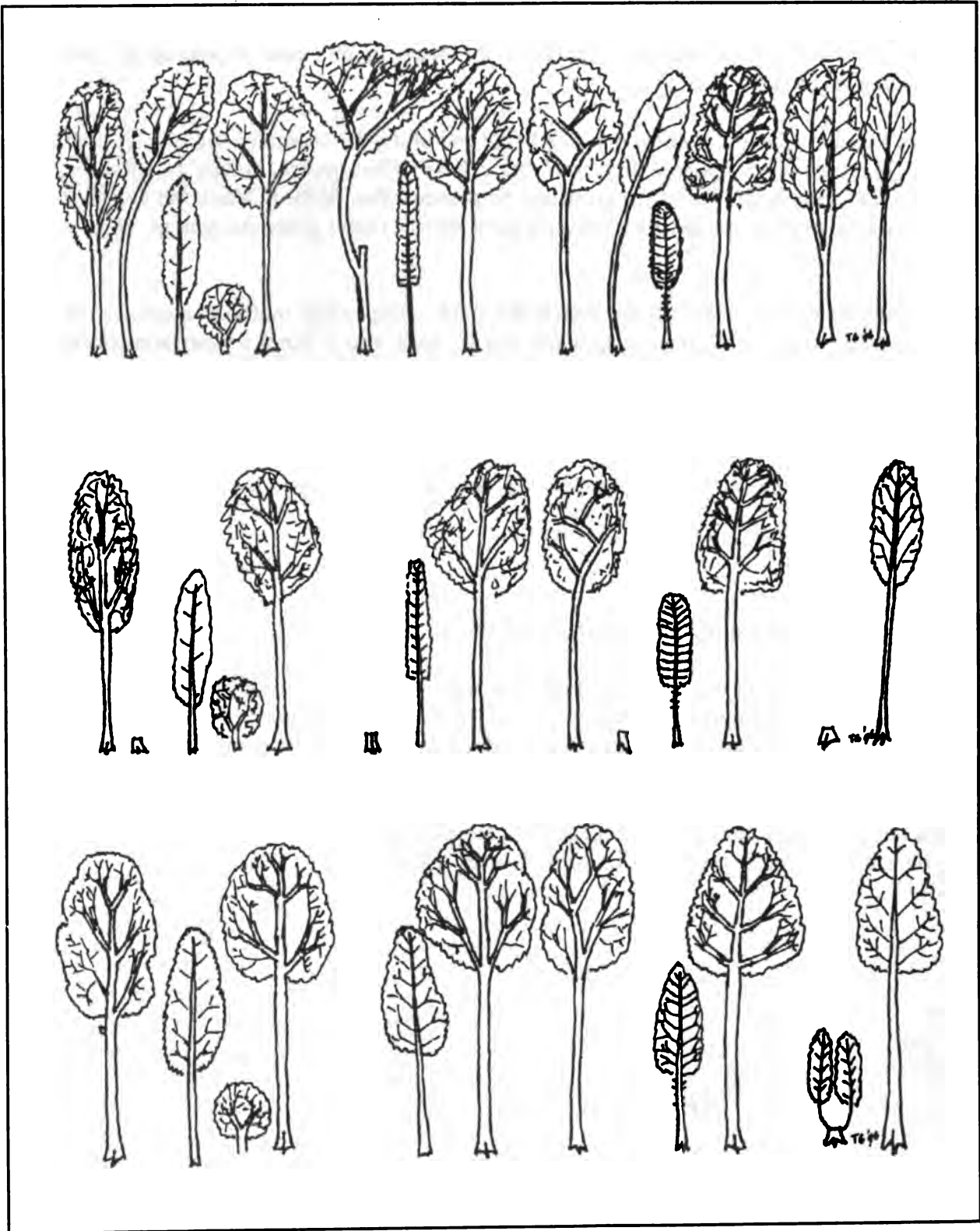
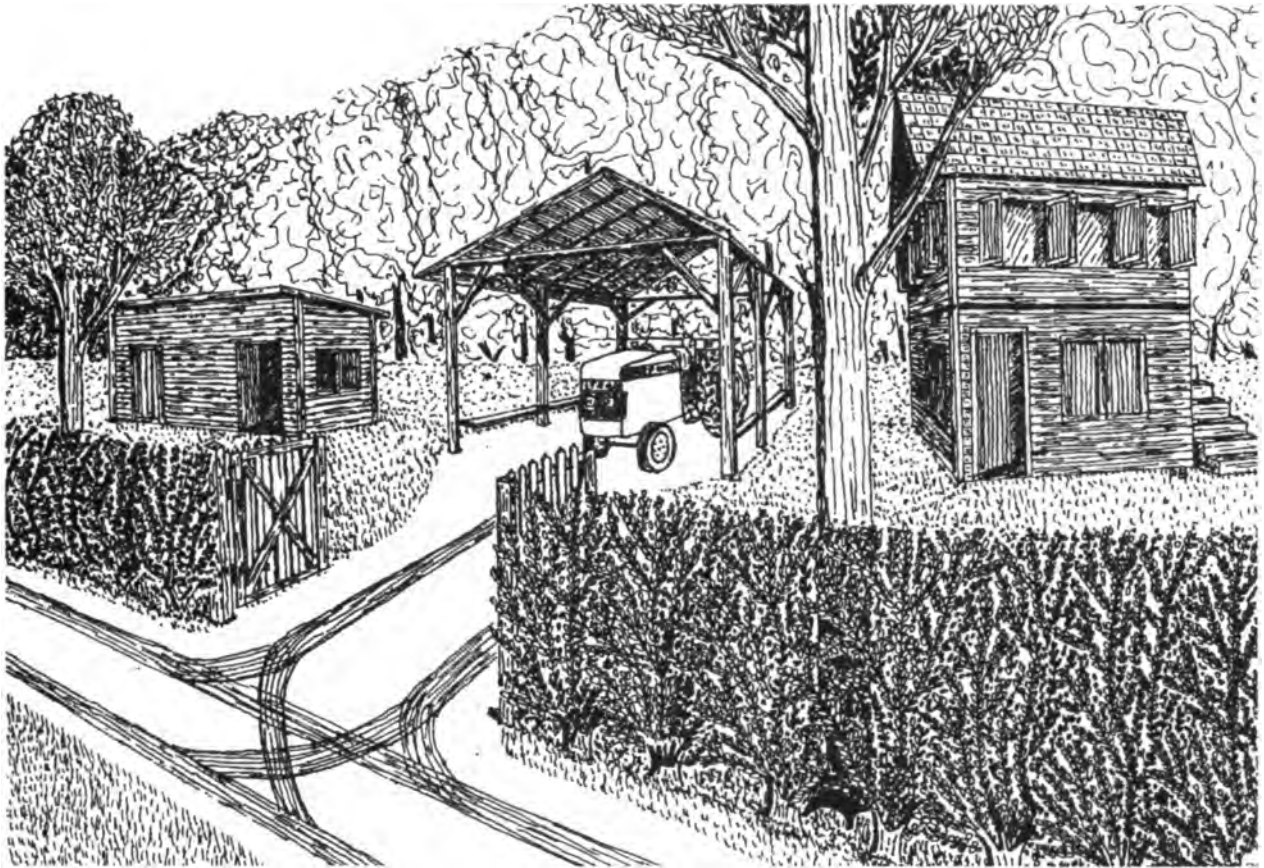


Figure 17: Thinning.

CHAPTER THREE

AGROFORESTRY PRACTICES



INTERCROPPING

PURPOSE AND POTENTIAL FOR GUYANA

Although every agroforestry practice is a form of intercropping, in this case it refers to a practice where a variety of trees, shrubs and crops are grown together on the same field in a haphazard or organized way.

To grow a wide variety of crops and trees together has several advantages. The production of food, fodder, fruits, wood and others is both diverse and continuous. This practice also ensures complete soil cover, which protects the soil against erosion, increases the organic matter in the soil, improves the soil structure, reduces evaporation and improves the micro-climate. The wide variety of vegetation encourages friendly insects and makes it more difficult for certain pests to do a lot of damage.

Intercropping practices can be sustainable and evolve over the years. Eventually, when the field is left fallow, fruit and timber trees will continue to produce, thereby increasing the value of the fallow field (see improved fallow).

Intercropping is widely used by the Amerindians in Guyana. Boxes 8 and 9 show two examples of intercropping practices in Regions 1 and 2. In some cases (Box 9), small adjustments to the existing farming method can help to sustain and improve these intercropping practices.

Intercropping practices in Moruca can be very diverse. The top tree level almost always consists of coconut trees, planted far apart so that they will not give too much shade.

Coffee grows under the trees; however, as the coffee trees are generally not pruned in Moruca, they can become quite tall. Other crops grown in the middle layer are bananas, plantains and bitter cassava.

At the lowest layer, a variety of crops are grown. These include peanuts, different types of peas and beans, corn, yam, sweet potato and others.

This type of farming provides the family with a variety of food for the household as well as some for marketing.

Box 8: Example of an intercropping practice in Region 1.

This example is from a recently started farm on white sand in Bethany. After cutting the trees and burning the field, the farmer planted a variety of crops together on a one-acre plot. These crops are pineapple, bitter cassava, bora, boullanger, sugarcane, pumpkin, melon, pepper, red beans, black-eye peas, plantains and bananas.

When the crops were small, the field was regularly weeded. As soon as the crops had grown bigger and covered the soil, natural weed growth was reduced.

This farmer can now harvest a variety of crops, both for home use and for marketing, almost continuously.

There are some ways in which this farm could be improved:

- More tree species could be planted. Nitrogen-fixing trees would help to sustain soil fertility on the white sands. More fruit and/or timber trees could be planted for the long-term benefit of the field;
- When weeding or harvesting, the farmer takes everything from the field and burns the residues. This results in a lot of organic matter and nutrients being removed from the field. Soil fertility and structure can be improved when the plant residues are left on the field to decompose or are placed on a compost heap.

Box 9: Example of an intercropping practice in Region 2.

STRUCTURE

The structure of an intercropping practice is always multi-layered with a wide variety of legume and non-legume trees, shrubs and annual crops and plants (see Figure 18).

In the first two years, mainly light demanding crops are grown. Later, when the higher layers of trees and tall shrubs are established, more shade-resistant crops are grown. Fewer trees can be planted in certain parts of the field to create an open space for growing light-demanding crops.



Figure 18: With intercropping, a variety of crops are grown together on the same field.

ESTABLISHMENT

After the usual clearing and burning at the beginning of the rainy season, the field is planted. Seedlings of fruit trees, timber trees and legumes are planted in a scattered fashion around the field, not too close together (minimum distance of 25 ft. apart). Some spots are left free of trees so as to be able to grow more light demanding crops, immediately or later on.

When planting, there is no special pattern to follow in mixing the different crops. However, some crops grow well together while others do not. This depends on their nutrient demand, root depth, type of crop (root, fruit or leafy), light demand and other characteristics of the crops used. Corn demands a lot of nutrients and can best be grown together with a legume crop like peanuts, black-eye or red beans. Legumes can also be grown between cassava when it is still small. Vine legumes (for example bora) can use the stalk of bananas or plantains to climb on. Pumpkin and melons grow well between pineapple. Sweet potato forms a good soil cover, preventing weed growth and soil erosion. Chili peppers and Neem can be planted to provide natural pesticides.

These are only some examples; there are many other possibilities. Use your own experience to think of other successful combinations.

MANAGEMENT

After the initial burning, no more burning is done on the field. After weeding or harvesting, the weeds and crop residues can be left in the field to decompose and enrich the soil with organic matter to provide nutrients and improve the soil structure. You can also place the weeds and plant residues on a compost heap to decompose and add the compost to the soil regularly (when planting a new crop). When there are no complete cover crops to protect the soil, it is recommended that the plant residues be left on the soil to protect it from erosion and to reduce the evaporation of water from the soil.

As the trees and crops grow, the different layers become more established and shade patterns change. The choice of species on a particular place will become more important.

The legume trees can be pruned regularly to open up the crown if shading is excessive, or to harvest mulch, fodder or small wood. Timber trees can be left to grow for many years. Occasionally, the lower branches can be pruned to improve stem quality. Useful tree species that evolve through natural regeneration can be protected to grow up and, if necessary, to be transplanted to a more suitable place in the field.

The lifespan of fruit and timber trees is usually longer than that of field crops. When leaving the field fallow, these fruits and trees can still be harvested. Even more of these useful species can be planted just before the fallow, increasing the economic viability of the fallow field (see improved fallow).

CHARACTERISTICS AND EXAMPLES OF SPECIES USED

Trees can be grown to produce fruit and timber. In addition, trees are also used to improve the fertility and structure of the soil and to improve the micro-climate of the field. Some characteristics of desirable trees are:

- preferably nitrogen-fixing;
- a deep root system to minimize competition with the crops;
- produce good leaf litter for mulch;
- light crown to give little shade;
- ability to resprout after pruning.

Examples of such desirable tree species are:

- *Acacia mangium*
- *Erithrina poeppigiana*
- *Gliricidia sepium*
- *Leucaena leucocephala*
- Neem, *Azadirachta indica*
- Trysil, *Pentaclethra macroloba*
- Whikie, *Inga rubignosa*

IMPROVED FALLOW

PURPOSE AND POTENTIAL FOR GUYANA

In traditional shifting cultivation, a period of crop cultivation is followed by a long fallow period, in which soil fertility will be recovered. During this period, the natural vegetation will regrow and the plot will not be used for a long time. When pressure on the land increases (through population growth or decreasing availability of agricultural land), often fallow periods are shortened and land is put into use while the soil fertility is not completely restored.

In the first place, it is possible to use improved fallow practices to shorten the fallow period by planting nitrogen-fixing shrubs or trees that speed up the restoration process. This method will here be called **biological improvement**.

In the second place, it is possible to use improved fallow practices to make the fallow period an economically viable part of the shifting cultivation cycle. In this case, tree species are planted to provide useful products (for example fruits, fodder, poles and medicines), thus the land will contribute to farm income and improved diet even while fallow. This method will here be called **economical improvement**.

In the selection of appropriate multiple-purpose tree species, it is often possible to combine both purposes (biological and economical improvement).

It is clear that the tree component in this practice has multiple purposes. The main one is to restore soil fertility by adding nutrients and organic matter to the soil. Another important purpose is the production of economically valuable products as food, fodder, medicines, poles and others. Furthermore, the trees provide a service through suppression of weeds, erosion control and reduction of pests and diseases.

Improved fallow can be applied in humid, semi-humid and semi-arid climatic areas.

Box 10 describes an economically improved fallow in an area where there is no severe land pressure. More biological improved fallow practices can be adopted in areas with land pressure.

The growing problem of shortened fallow periods is being felt in different parts of the Guyanese hinterland. There is land pressure because of the limited amount of agricultural land available in Amerindian reservations. Farmers often try to overcome the problem of lack of soil fertility after a short fallow by using chemical fertilizers to grow their crops. This solution has several disadvantages: very little information is available for hinterland areas on which type of fertilizer to use and how much fertilizer should be added to the soil; fertilizers are expensive and in most places there is no regular supply.

Agroforestry practice "Chagras" of the indigenous Amerindian communities of medio Caquetá (Colombian Amazon)

The indigenous population of the region of medio Caquetá, Colombia, consists of various tribes, but they all share the following characteristics:

Their communities are governed by traditional leaders, headed by the chief and the village elders. The culture is being passed on orally in which the "mambe" (coca) and the "ambil" (tobacco) play an important role.

Generally, the indigenous production system takes place in three different locations: the river, the forest and the agricultural areas, between which many complementary relations exist. These communities have a subsistence economy based principally on shifting cultivation, hunting, fishing and the gathering of forest products.

The agricultural system is established with slash and burn and is composed of "chagras" (fields) in which during the first two or three years, annual food crops dominate. After that, the chagras are dominated by fruit-producing trees and shrubs. The life span of these fruit trees determines the productive life of these orchards. The fruit trees are either spared during the initial cutting and burning of the forest or planted together with or after the annual crops.

Every family group generally establishes one or two "chagras" of two to five acres per year. As a result, the family owns a number of "chagras" that equals or surpasses the number of years the family lives in the area. The "chagras" can have a productive life of 35 years or more.

Thanks to this continuous process, every family has a very diverse diet. Over 70 different plant species are being cultivated. Of the 38 most important species, 16 are annuals (including cassava, corn, tobacco, pepper, peanut, beans, etc.), 16 are medium-term (5 to 15 years) crops (including banana, plantain, coca, pineapple, cocoa, cashew, avocado, etc.) and 6 are long-term (fruit) crops (including giant cashew, star apples and others).

Box 10: Example of an advanced economic improved fallow practice (after Vélez and Vélez (1992) and Vélez (1991)).

For Guyanese farmers, improved fallow has good potential. Whether the emphasis will be on biological improved fallow or economical improved fallow is partly determined by the pressure on the land, but mainly by the preference of the farmer.

An improved fallow can always be followed by another agroforestry cropping practice, like alley cropping, shade trees, living fences or others.

STRUCTURE

The structure of an improved fallow can vary from a single layer stand with only one specie to a multi layered stand with various species (see Figure 19).

An example of the first case is a densely planted legume specie. Its main purpose is to quickly restore soil fertility. Depending on the specie you choose to use, it can also provide some products like poles and fodder.

An example of the second case is a combination of legume and non-legume trees, shrubs and weeds. Because of this variety, it will provide more products and services like food, medicines, erosion control and reduced chances of pests and diseases.

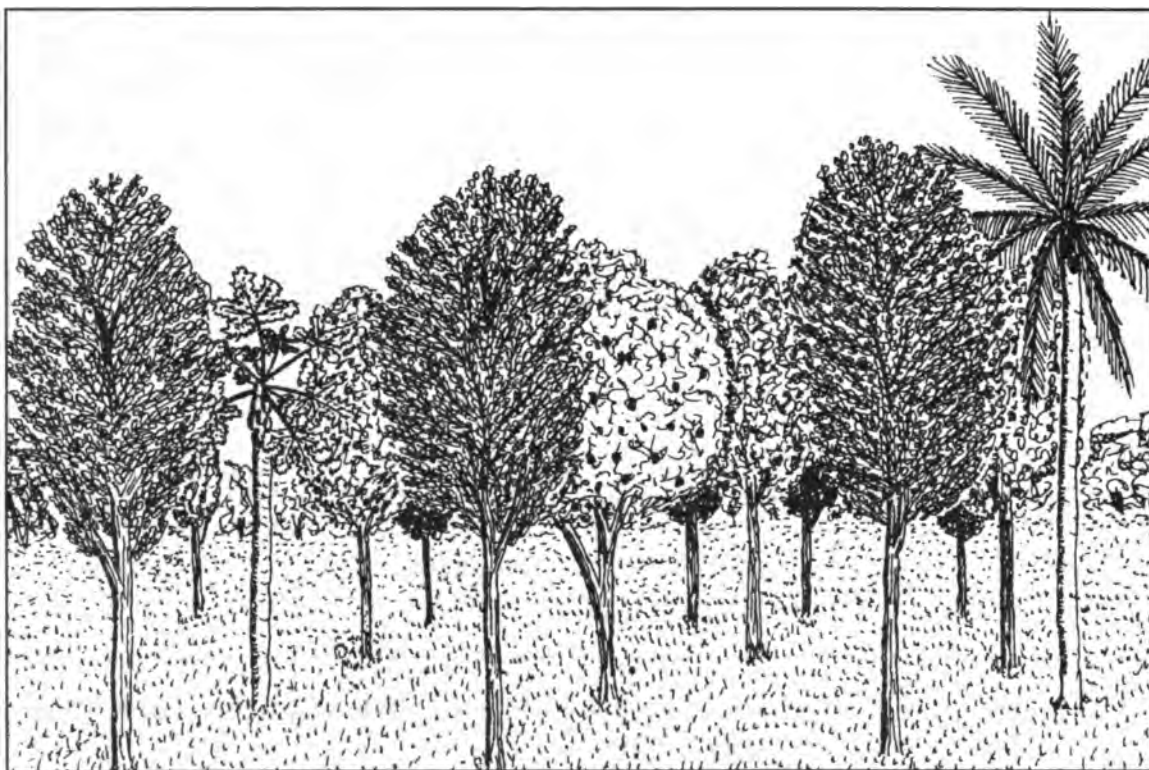


Figure 19: Structure of a combined biological and economical improved fallow, with nitrogen fixing trees and fruit trees.

When plans exist to use another agroforestry practice after the fallow, desired species can be planted in specific locations (shade trees, lines for alley cropping) with the other trees remaining in between. In this case, the field cannot be burned after clearing, as this would kill the newly planted trees.

When trees are planted that are to remain after the fallow (for instance fruit trees), they should be spaced in such a way that they can be incorporated into the following cropping system.

ESTABLISHMENT

You can start the establishment of the improved fallow practice at the beginning of the planting season following the previous crop harvest.

The spacing of the trees depends on your plans following the fallow period. If the field is to be cleared completely for crop cultivation, spacing is not very important. For a biological improved fallow, you will need many leguminous shrubs or trees to create a dense stand. The cheapest way to achieve this is either to take stem cuttings and plant these directly in the field or to collect the seeds and plant those directly in the field. Some seeds like *Leucaena leucocephala*, *Gliricidia sepium* and *Acacia mangium* need pre treatment (see description of the tree species). Plant the seeds close together, 3-4 ft. apart.

The use of different species will increase the diversity and decrease the risk of pests and diseases.

Seedlings of other, more economically valuable species (fruit trees, non-leguminous wood producers and others), and important trees like Neem, can be planted in between. Seedlings of these species can be produced in an on-farm nursery. Often these trees have a longer life span than the legumes. It is therefore important to carefully choose the planting place, if you want to incorporate them into the new cropping system.

Natural regeneration of local trees should also be supported so as to biologically enrich the improved fallow.

If it has been decided to use another agroforestry practice in the following crop cycle, improved fallow practices can be used to establish the tree component of the following agroforestry practice. Spacing of the trees for the improved fallow then becomes more important.

For example, suppose you want to start an alley cropping practice. When establishing your improved fallow, you can plant the required species for the alley cropping in lines and plant the other trees/shrubs in the alleys (see also the establishment of alley cropping).

MANAGEMENT

After the planting, it is very important to protect your small trees against hungry animals. Most legumes are very attractive to cattle and game. Once the trees are big enough, cattle can be allowed to graze there. Their manure will help to enrich the soil.

After establishment, the trees/shrubs require very little management. If the stand is very dense, it can be thinned by cutting some of the trees. The wood could be used for stakes and firewood.

When fruit trees and other valuable trees are planted, more intensive management is necessary. It will be necessary to open up a small area around each tree, regularly, to set them free and stimulate their growth.

When the fields are cleared after the fallow period, some of the trees/shrubs can be left to supply seeds for the next fallow period.

CHARACTERISTICS AND EXAMPLES OF TREE SPECIES

The tree species used in an improved fallow practice should preferably have the following characteristics:

- nitrogen-fixing;
- a relatively short life span;
- a relatively small root system makes clearing after the fallow period easier;
- easy to propagate.

Examples of tree species that can be used are:

- *Acacia mangium*
- *Casuarina equisetifolia*
- *Erithrina poeppigiana*
- *Gliricidia sepium*
- *Leucaena leucocephala*
- Neem, *Azadirachta indica*

- Tonka bean, *Dipteryx odorata*
- Maporokon, *Inga alba*
- Whikie, *Inga rubiginosa*
- Trysil, *Pentaclethra macroloba*
- Red manariballi, *Pithecellobium gongrijpii*
- Serebedan, *Swartzia spp*
- Itiki borolalli, *Swartzia spp*
- A variety of fruit trees, nuts and non-leguminous trees that produce wood, medicines and any other product you want to have.

ALLEY CROPPING

PURPOSE AND POTENTIAL FOR GUYANA

The main objective of alley cropping is sustaining and improving soil fertility, to allow for both a more intensive and a longer cropping period.

In alley cropping, fertilizers are produced on the farm. The different processes involved here are: 1. nitrogen fixation, when nitrogen-fixing trees are used; 2. the nutrient cycle will be optimized or restored; and 3. the organic matter content in the soil increases. The trees will also improve the soil structure and micro-climate and will protect the soil against erosion. Furthermore, mulching will reduce the growth of weeds. Other important benefits are that fodder and small-size wood can be collected from the trees.

Alley cropping is an alternative for shifting cultivation and integrates modern science with the wisdom of traditional shifting cultivation. Because of increased pressure on land, farmers often have to shorten the fallow period and intensify crop production (growing more crops on the same piece of land). When the soil fertility of the land is not suitable to allow an increase in production under the traditional farming methods, then alley cropping becomes an important alternative.

This is the case throughout Guyana. Amerindians farm on infertile and fragile soils. Since they settle in communities and the amount of land available in the reservations is limited, the fallow periods in the shifting cultivation cycles are shortened, resulting in a loss of soil fertility and decline in crop production. The use of chemical fertilizers is only a short-term solution and has many disadvantages (cost, irregular availability, lack of information, unsuitability for sandy soils).

The tree component in the alley cropping practice fulfills the role of the trees in the fallow period (restoring and maintaining soil fertility and the nutrient cycle), which enables intensive crop production in the alleys over a longer period, maybe even permanently.

STRUCTURE

In alley cropping, lines of leguminous trees and/or shrubs are grown between alleys of annual crops. The tree lines are at regular distance from each other and densely planted. Through intensive coppicing, the trees/shrubs are kept short.

All the crops normally grown can be produced in alleys, for example peanuts, beans, peas, cassava, pineapple, sweet potato, pumpkin, melon, corn, banana, plantain, and many more.

Similarly, other non-leguminous species, fruit trees, Neem and others can be integrated within the system.

ESTABLISHMENT

The first step in starting alley cropping on your farm is making the tree lines. For the establishment of the tree lines, mostly seedlings are used, but you can also put seeds directly in the soil or use cuttings. If you want to use seedlings, you can easily grow them in a small nursery on or near your farm. It is cheaper to plant the seeds directly in the soil, but it will take longer to establish. Some seeds like *Leucaena leucocephala* and *Gliricidia sepium* need pre treatment (see Tree Descriptions).

The lines of trees are planted at regular distances: 12-24 ft. apart. Within the lines, trees are planted closer together: 1-6 ft. apart. The spacing depends on the tree species used, climate, soil conditions and the space required by tillage equipment (if used). The humidity of the site is very important. Closer spacing is possible in humid areas while more distance is required in drier areas, due to the competition for water between the trees and between the trees and crops.

Preferably the lines should be planted in an east-west direction, so that shading of the crops by the trees is minimized; on slopes, the trees should always follow the contour lines to prevent erosion.

Along the borders of the field and/or at the ends of the tree lines, fruit trees or other useful species like Neem can be planted.

An alley-cropping practice can also be a follow-up of an improved fallow practice. The trees are then established during the fallow period (see improved fallow) and only need to be coppiced to the required height.

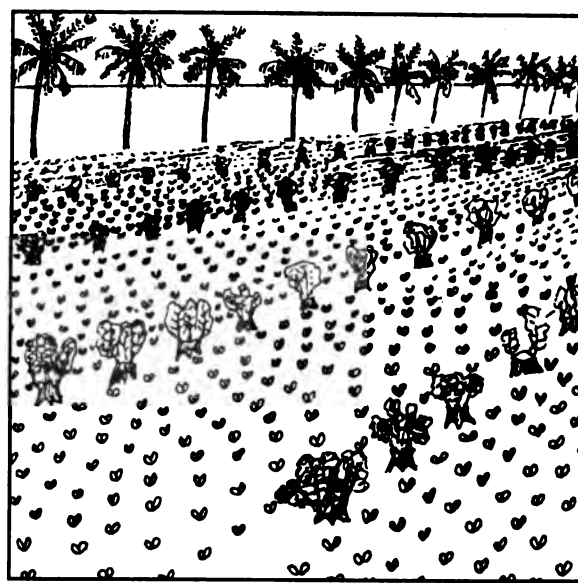
MANAGEMENT

Alley cropping needs intensive management. The trees need to be pruned often to reduce their shade and water competition for the crops, and to make leaves and branches available for mulching, fodder and other products. Normally, pruning should be undertaken four to five times per year. Sometimes the protection of the crop requires pruning more often, maybe even monthly.

It is advisable not to prune the trees during the first year, so that they will have time to develop a good root system. However, if during this first year it is seen that the trees are providing too much shade, it may be necessary to start pruning.



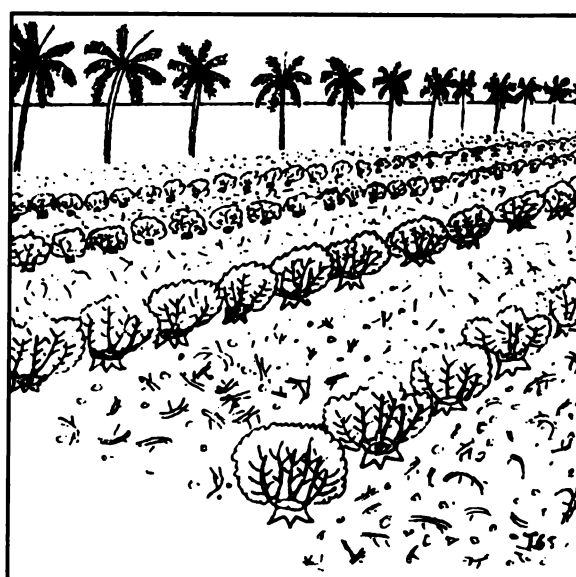
20a: Copping of the trees before planting.



20b: As the crops germinate, the trees resprout.



20c: When the trees start shading the crop, they can be pruned or coppiced again.



20d: After the harvest of the crop, the trees are left to grow until the new planting season.

Figure 20: Management cycle of an alley cropping practice.

During the first year (until the first coppicing), the young trees will benefit from the weeding, fertilizing and other activities carried out on crops grown in the alleys. This will induce good establishment of the tree lines. In the later stages, after starting the coppicing and pruning of the trees, the crops will benefit from the activities carried out on the trees.

After the trees are established, they must be managed carefully (see Figure 20). At the beginning of the cropping season, after preparation of the land for planting, coppice the trees at a height of 1½-2 ft. (see Figure 20a). This means removing all the branches and cutting the stem to the preferred height. The leaves and twigs from the trees should be placed on the prepared alleys as mulch. This mulch will reduce evaporation of water from the soil and prevent the soil from overheating. In this way, the mulch protects the young crop that is planted in the alleys. In time, the mulch material will decompose and the organic matter content in the soil will increase. The nutrients from the trees will thereby become available to the crop.

After being coppiced, the trees will resprout quickly (see Figure 20b). While the crops are on the field, the trees can be pruned by cutting those branches that start to shade the crop (see Figure 20c). Some branches can also be pruned when fodder and/or mulch are needed, even when the trees do not interfere with the crops. If bigger wood is preferred and interference with the crop is not excessive, the branches can be left to grow, being pruned only once or twice a year.

After harvesting the annual crop, the cycle will start again (see Figure 20d). When preparing the land for the new cropping season, it will be necessary to coppice the trees as described above.

When you prune or coppice nitrogen-fixing trees and leave the twigs and leaves to decompose (rot) on the field, the nitrogen and other nutrients are released into the soil. This nitrogen will become available for other plants. This means that coppicing the trees at the beginning of the cropping season will make extra nitrogen available to the young crop.

When the leaves and twigs are used as fodder, nutrients are taken from the field and need to be returned. This can be done by applying animal manure to the soil.

Although alley cropping allows long periods of continuous cultivation on one plot, a short fallow period will improve the sustainability and crop production of the alley-cropping system.

If the farming system permits, a short fallow period can be integrated into the farming cycle. A rotation system (8 years crop production, 2 years fallow) is possible. During the fallow period, no crops are grown for 2 years. Small animals can be allowed to graze in the alleys. This fallow improves the productivity of the tree lines. The trees will grow better, have a higher survival rate and are better able to regenerate and maintain soil fertility.

During the fallow period, the trees can be pruned, if necessary, to produce mulch, fodder or other products as required. After the fallow period, some bigger wood can be harvested.

Crop yield will improve after the fallow period.

CHARACTERISTICS AND EXAMPLES OF TREE SPECIES

The tree species used in alley cropping practices should have as many as possible of the following characteristics:

- it should be able to resprout quickly after coppicing/pruning;
- it should have mainly deep roots and few shallow roots, or the shallow roots should be easy to prune without damaging the tree;
- it should be nitrogen fixing;
- it should give good leaf litter to use as mulch and/or fodder;
- it should have a light, open crown that lets through sunlight to reduce the shading of the crops;
- it should be able to fulfil local needs (poles, fodder, and other products the farmer would like to obtain from the trees);
- it should be adapted to the local site (sandy soils, drought, flooding, insects, and others).

Examples of tree species that can be used are:

- *Erithrina poeppigiana*
- *Gliricidia sepium*
- *Leucaena leucocephala*

TREES AND PASTURE

PURPOSE AND POTENTIAL FOR GUYANA

You can approach a practice which combines trees and animals in two ways: in the first case the animals are the main component and the trees secondary and in the second case, the trees are the main component and the animals secondary.

An example of the first case is pasture land with dispersed trees. This can be important to you if your pasture land is degrading (due to loss of soil fertility), or if you want to improve the conditions for your animals by providing shade and more variety in their diet. These benefits can be provided by trees.

Under these circumstances, leguminous trees are often planted. They enrich the soil (nitrogen-fixing) and provide good fodder (most legumes are very attractive to cattle). In less degraded areas, you can of course also add non-leguminous species that provide products you need, such as fruits, nuts, Neem and others. Apart from the above mentioned products and services, the trees also provide wood products (poles, firewood), improve soil structure and add organic matter to the soil.

This method has special potential for areas in the Rupununi and Pakaraimas, where cattle is reared.

The second method, with trees as the main component, can be important when you have a fruit orchard. An example of a fruit orchard with cattle rearing is given in Box 2 on page 7).

The animals graze under the trees, thus reducing the need for weeding, while fertilizing the soil with their manure. Also, prunings from the fruit trees can be fed the animals to improve their diet. The milk and meat products from the livestock will provide you with additional income.

This practice has special potential in areas with fruit orchards, such as Region 1 and the Pomeroun, or the Rupununi cashew plantations.

Both tree and pasture practices are often combined with wind breaks and/or living fences.

STRUCTURE

Both practices are carried out using two layers - a tree layer and an undergrowth layer of grasses and legumes such as kudzu. Animals graze inside. The tree layer consists of a variety of species, thus giving a variety of products (fruits, fodder, nuts, wood, pesticides, etc.) and helping to reduce the risk of pests and diseases.

Trees in pasture land are often scattered at random, but it is also possible to plant them in lines, according to your preference (see Figure 21). You should, however, never plant the trees so densely that they interfere with grass production.

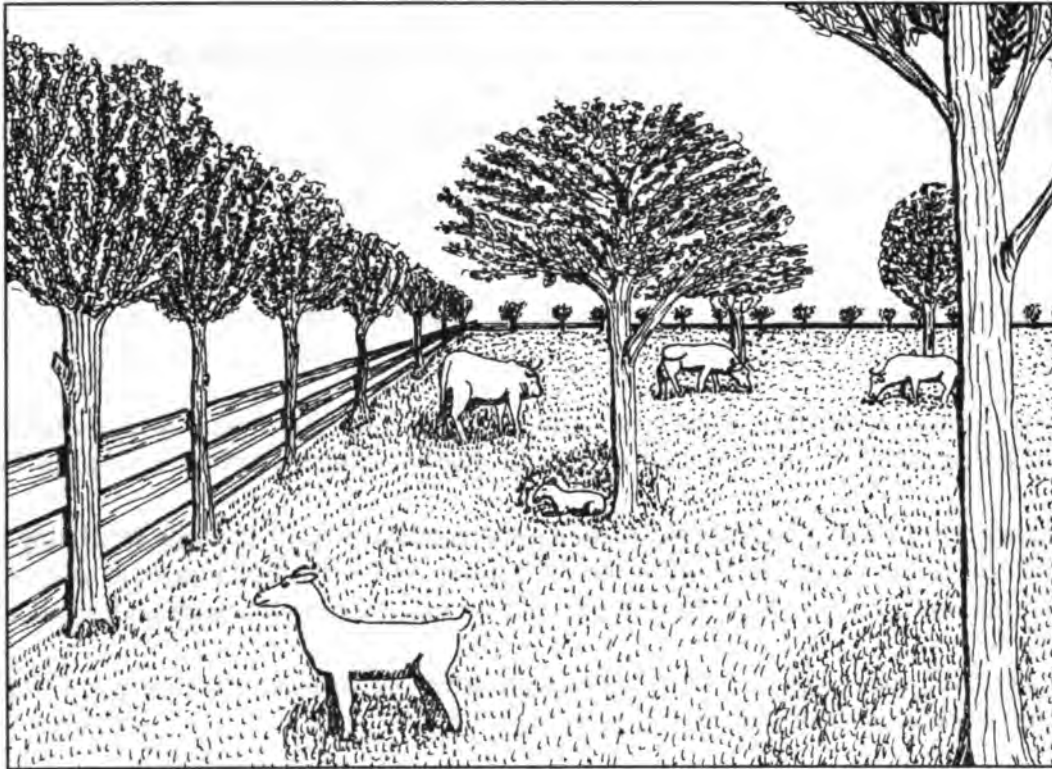


Figure 21: Dispersed trees on pasture land.

A fruit orchard is often (but not necessarily) more structured, with the fruit trees planted in lines (see Figure 22).

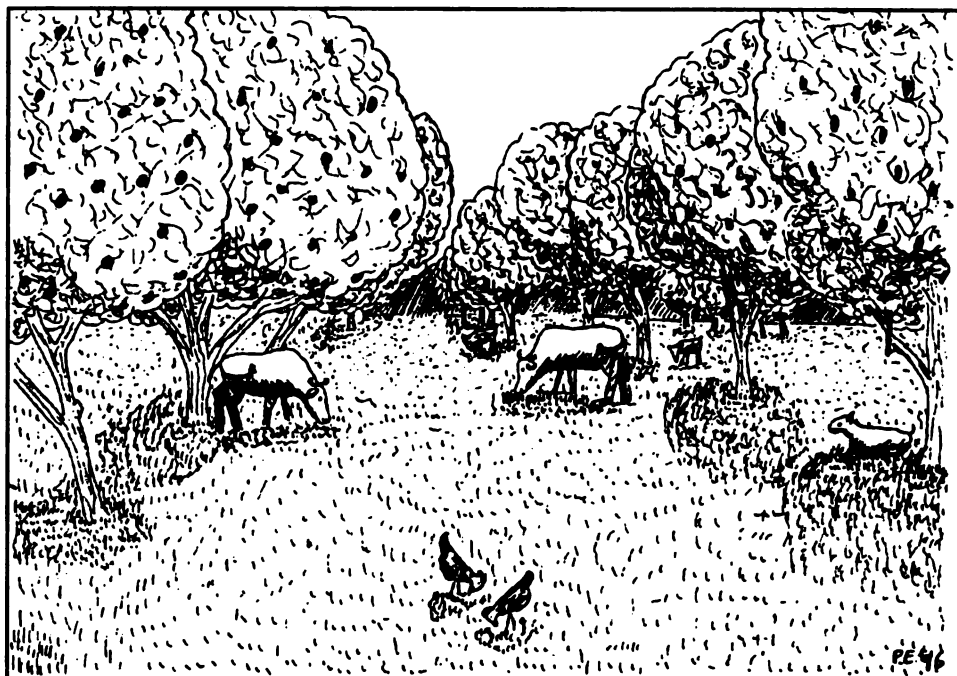


Figure 22: Animals grazing under fruit trees.

ESTABLISHMENT OF TREES ON PASTURE LAND

For the establishment of trees on pasture land, it is best to use seedlings. Since the young trees need protection against animals, the use of seedlings minimizes the period during which protection is needed. The seedlings can be grown in an on-farm nursery. Also, big stem cuttings of 6 ft. or more can be used, as these are less easily damaged by cattle. Trees coming up through natural regeneration can also be retained and protected from animals during their early phase.

The trees should be planted relatively far apart, for example 40-60 ft. from one to the next. In drier areas, spacing should be even wider (so as to reduce competition for water), while in more humid areas, you can plant the trees closer together.

You should plant a variety of leguminous trees, nut and fruit trees, as well as some Neem, so as to make natural pesticides and produce nuts and fruits.

MANAGEMENT OF TREES ON PASTURE LAND

In the initial period, the seedlings need protection against animals. As there are not too many trees involved, they can be protected individually. This can be done by making a small fence out of thorny branches, bamboo, wood or other material around the trees. Some fast growing leguminous species will take 1.5 to 2 years to grow big enough to be safe from cattle. Other species may take longer. Weeding around the young seedlings is necessary for them to be established.

Once the trees are established, you can regularly prune some branches from the trees to feed to the animals to improve their diet. Wood and other products can also be harvested. Care should also be taken not to remove too many branches or to prune too often.

As mentioned before, the spacing of the trees is generally wide. On a slope it might be necessary to plant more trees. The animals seeking shade under the trees intensively trample the soil. This can increase the risk of erosion. When you see this happen, it is clear that you will have to plant more trees on the slope to spread the animals and minimise the intensity of their trampling.

ESTABLISHMENT OF A FRUIT ORCHARD

Seedlings are normally used to establish an orchard. Spacing will vary with soil type, species and variety used, as each fruit tree species has its own optimal spacing. Information on spacing can be obtained from your local agricultural extension officer or from nurseries that produce and sell fruit trees.

Use a variety of species in your orchard. This will diversify your production, spread peaks in labour demand and reduce the risk of pests and diseases. Plant some Neem trees in between or along the borders, so as to have material for pesticides.

Management of a fruit orchard

Fruit tree seedlings also require protection against animals during the early years. As the fruit orchard is often more densely planted than the trees on pasture land, it is tedious and expensive to protect each individual seedling. An alternative method to protect the seedlings is to keep the animals outside the orchard until the trees are big enough, or to plant only part of the orchard initially and close this off to animals. During the period that the trees need protection, a cut-and-carry system can be used where grass can be cut from the orchard to feed the animals.

Once the fruit trees are established and bearing, they will need regular (yearly) pruning. The prunings can be fed to the animals to improve their diet.

CHARACTERISTICS AND EXAMPLES OF TREE SPECIES

The tree species used in pasture land should preferably have the following characteristics:

- nitrogen-fixing;
- fast growing (especially in the early stage);
- resprout easily after pruning;
- produce good fodder;
- deep rooting system with little shallow roots;
- should not suppress the growth of grasses.

Examples of tree species are:

- *Acacia mangium*
- *Erithrina poeppigiana*
- *Gliricidia sepium*
- *Leucaena leucocephala*
- Neem, *Azadirachta indica*
- Tonka bean, *Dipteryx odorata*
- Maporokon, *Inga alba*
- Whikie, *Inga rubiginosa*
- Trysil, *Pentaclethra macroloba*
- Red manariballi, *Pithecellobium gongrijpii*
- Serebedan, *Swartzia spp*
- Itiki borolalli, *Swartzia spp*

The fruit trees used in the orchard should have their crowns high enough so that the animals can not reach them. Furthermore, they should not be so dense as to prevent grass from growing under the trees. Citrus trees, cashew and coconuts are examples of trees with these characteristics.

LIVING FENCES

PURPOSE AND POTENTIAL FOR GUYANA

Living fences are lines of trees and/or shrubs. You mostly see them around pasture land or animal enclosures, where they serve to keep animals inside enclosed areas. Living fences are also found around crop fields, to keep animals out, and around houses where they provide shade, windbreaks and privacy.

Use a living fence around a place where you do not want people or animals to walk in and out freely. A living fence works as well as a wire fence, but it looks much friendlier and can provide you with other benefits from trees and shrubs.

Apart from the above-mentioned benefits, living fences can also provide mulch, fruits, bee forage and wood. They also help in soil conservation and can add beauty to your homestead.

Living fences can be established in every part of Guyana where there is a need to control the movement of cattle (and/or people). This practice can be combined with growing trees on pasture land or orchards with cattle rearing.

Living fences around house yards are important for savanna areas, where they serve as windbreaks, provide shade and protect chickens around the house against birds of prey and other predators.

STRUCTURE

A living fence is a densely planted row of shrubs. Trees are planted in between (see Figure 23).

Different species of shrubs and trees can be used to stop the movement of animals and provide the products important to you. Thorny bushes can be used, but they can also be problematic when being trimmed. Other species produce a kind of milk that the animals do not like. If species are used that the animals will browse on, the fence should be dense enough so that they can not pass through. This can be achieved by planting a double row of shrubs.

Other valuable tree species can be planted within the fence and benefit from the protection or support provided given by the fence.

Another, more extensive, type of living fence is made by planting trees at regular intervals. The stems can then be used as living fence posts, to support another wire or wood fence.

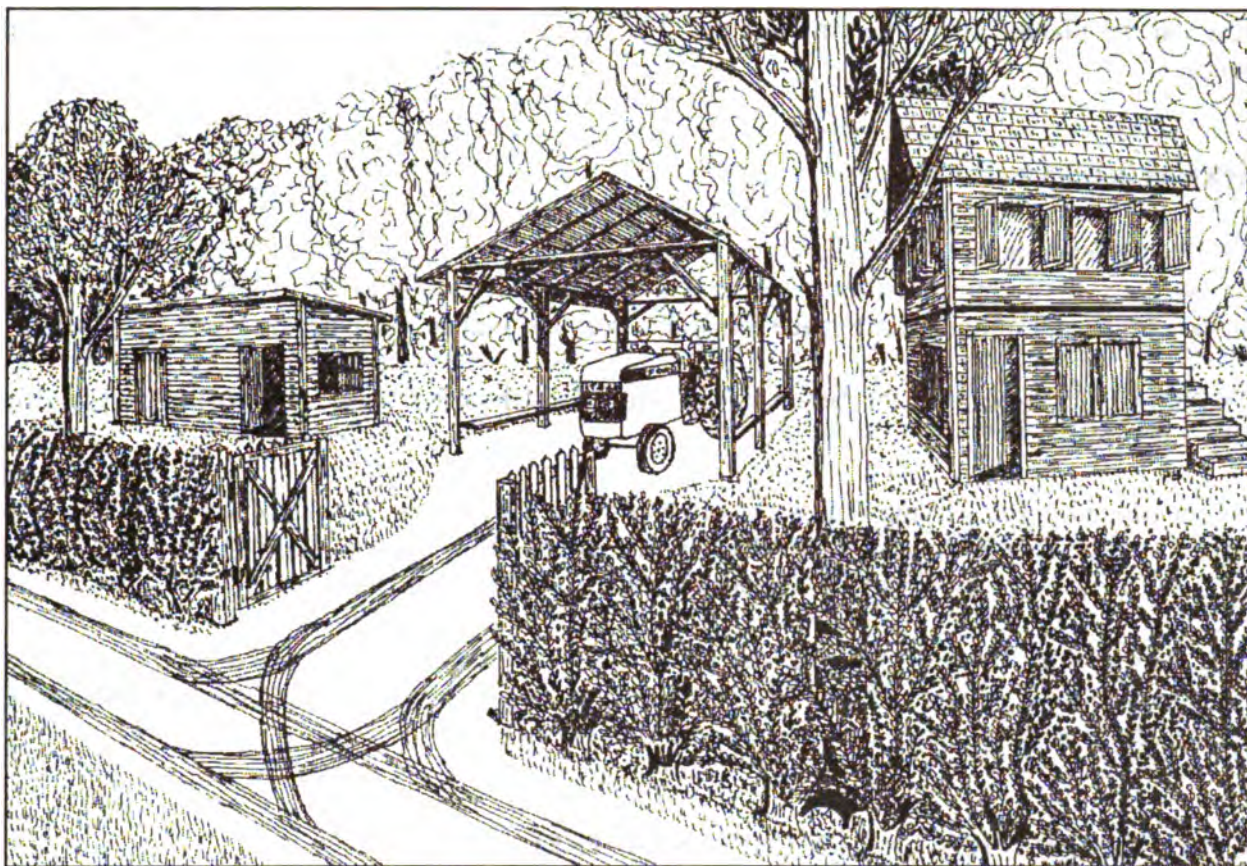


Figure 23: A living fence can be a friendly way to prevent people from trespassing.

ESTABLISHMENT

For the establishment of a living fence you will need many shrubs or trees. There are different methods you can use for the establishment of the fence. You can plant the seeds directly in the soil, but the disadvantage of this method is that it will take a relatively long time before your fence is well established.

From some species (*Gliricidia sepium*, *Leucaena leucocephala*, *Erythrina poeppigiana*, *Acacia mangium*) it is also possible to plant cuttings. Take cuttings from the mother trees 1-2 in. in diameter and 3-6 ft. long. Strip all the leaves off the cutting. Cut the base of the cutting with a sharp knife or cutlass in a slight angle. Plant the cutting, base down, about ½ ft. deep in the soil, which is first loosened. The advantage of this method is that when the cuttings are well established, a high fence is created immediately.

A third method you can use is planting of seedlings, which you can grow yourself in an on-farm nursery, thereby reducing costs.

The trees or shrubs should be planted close together, but not closer than ½ ft. apart. A second row can be planted the same way about 1-2 ft. from the first row, to create an even denser fence.

MANAGEMENT

The living fence needs regular lopping. Depending on the species used, this can be done once or twice a year. Lopping will prevent the fence from overgrowing and will keep it in a suitable shape. More side branches are made when the trees are lopped, making the fence more dense.

The branches can be used for mulch, composting, fodder or fuelwood, or to make cuttings for new plantings.

As mentioned before, living fences are often combined with trees for the production of wood. When you use species in your fence that produce good wood, you can allow some stems of the fence to grow large by removing the other stems from the same stump.

It is also possible to plant different species in the fence. Open up the fence a little around the planted seedlings, so there will be less competition. Do not open the fence too much, otherwise the seedlings will not benefit from the protection provided by it.

CHARACTERISTICS AND EXAMPLES OF TREE SPECIES

Some characteristics of tree species used for living fences are:

- relatively fast growing;
- propagation from large cuttings possible;
- can withstand regular lopping.

Examples of tree species are:

- *Acacia Mangium*
- *Leucaena leucocephala*
- *Casuarina equisetifolia*
- Neem, *Azadirachta indica*
- *Erythrina poeppigiana*
- *Gliricida sepium*

WINDBREAKS OR SHELTERBELTS

PURPOSE AND POTENTIAL FOR GUYANA

Wind, especially if it is hard and constant, has several negative effects for farmers: it causes wind erosion, whereby the fertile top soil is blown away; it increases the evaporation of water from the soil, making the soil drier; and it can cause physical damage to crops. These are just the most important effects.

To reduce wind speed, thus the negative effects caused by strong wind, windbreaks or shelterbelts can be planted. Windbreaks and shelterbelts refer to the same agroforestry practice, but for our purposes, the term windbreak will be used. Trees can reduce wind speed up to a distance of 20 times the height of the windbreak, thereby reducing wind erosion and water losses from the soil.

Furthermore, tree stands will enrich the soil with organic matter, and dust particles (containing nutrients from the top soil carried by the wind) will be caught by the trees and caused to fall back on the soil. The trees themselves may also provide a variety of products.

Windbreaks are most commonly used in areas where either large-scale farming takes place or where sufficient land is available bordering the farms, because windbreaks can occupy a rather large area. For small-scale farming, a living fence will often be sufficient to function as a windbreak.

Windbreaks are most useful in areas having high wind speeds coming mainly, and for long periods, from one direction and where the soil has a loose structure and is dry for many months. In Guyana, these situations are found predominantly in the Rupununi, with the open savannahs enhancing the wind speed.

STRUCTURE

Windbreaks are single, double or triple lines of trees. They can consist of one line of trees planted rather close together, or an extra line of small trees or tall shrubs can be planted on the windward side, in which case the trees in the lines are planted a little further apart (see Figure 24). Sometimes an extra line of small shrubs or a ground cover of grasses and plants is planted on the windward side to protect the soil fully against erosion.

To be most efficient, the windbreak should be planted at right angles to the prevailing wind, on the upwind side of the land which is to be protected. A multi-storey windbreak (using trees and shrubs) is most efficient. A variety of trees, both fast- and slow-growing, improve the sustainability of the windbreak and reduce the risk of damage by pests and diseases.

It is very important that the windbreak be not too dense. If the wind is blocked completely by the trees, it will cause turbulence over the crops, causing even more damage than if there were no windbreak. The windbreak must allow the wind to go through, but slow it down (semi-permeable). The trees and shrubs should therefore not be planted too close together.

Small gaps in the tree lines must be avoided as much as possible, since wind is funnelled through them at a higher speed, resulting in an increase of adverse effects.

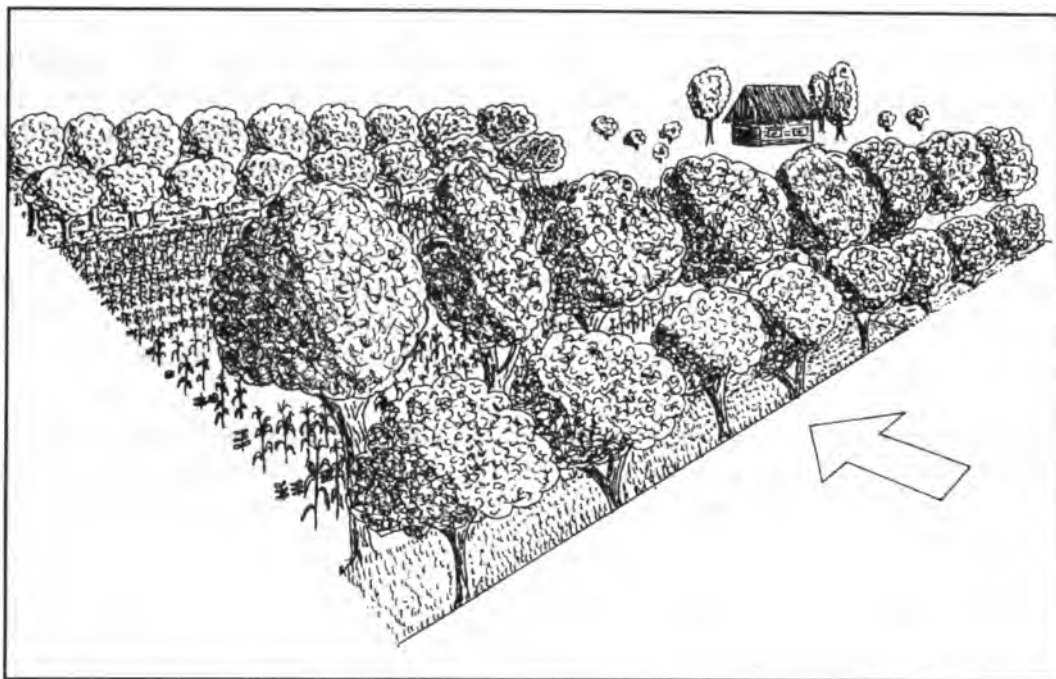


Figure 24: Windbreaks consist of trees in lines of different height on the windward side of the field.

ESTABLISHMENT

For the establishment of a windbreak, seeds, seedlings and/or cuttings can be used, but the use of seedlings is more common and windbreaks will be established faster. The seedlings can be grown in an on-farm nursery.

If a single line of trees is used, then plant the trees 5-7 ft. apart in the line. If two or more lines are used, then plant the trees 12-15 ft. apart in the line. The second line of small trees or tall shrubs should be planted 9-12 ft from the first line (upwind). The trees in this line are also planted 12-15 ft. apart, but in such a way that triangles are formed with the trees of the first line. Other lines with smaller shrubs can be planted 9-12 ft. upwind from the line of small trees.

MANAGEMENT

In the early stages, the seedlings need to be protected against animals and fire. Weeding around the seedlings will also be necessary, and dead seedlings should be replaced.

As they grow, the trees need pruning or pollarding in order to maintain the density of the windbreak and reduce shading of the crops. Also, dead and blown-over trees need to be replaced.

Management of the trees is primarily aimed at maintenance of the functions of the windbreak. This is not very intensive, but it is important to keep a close eye on the windbreak and carry out the necessary maintenance work in time. If this is not done, the windbreak may become dense or gaps may occur, resulting in increased damage to the crops as mentioned above.

Leaves and branches can be harvested for fodder and other uses as long as no harm is done to the shape of the windbreak. Fast-growing trees with a relatively short life span need to be replaced every few years. These trees can be harvested for wood.

CHARACTERISTICS AND EXAMPLES OF TREE SPECIES

In general, trees with a narrow, vertical growth are best for windbreaks so as to minimize land requirements. Ideally, a variety of fast- and slow-growing trees with different shapes are used.

It is preferable that the trees be evergreen. If this is not the case, they should have their leaves during the period that the wind speed is highest and crops are grown.

The use of nitrogen fixing trees enhances soil improvement.

Examples of tree species useful in windbreaks are:

- *Acacia mangium*
- *Casuarina equisetifolia*
- *Erithrina poeppigiana*
- *Gliricidia sepium*
- *Leucaena leucocephala*
- Neem, *Azadirachta indica*

SHADE TREES

PURPOSE AND POTENTIAL FOR GUYANA

Shade trees are primarily used on coffee and cocoa plantations. Planting shade trees over coffee is not absolutely necessary, as coffee trees produce well when grown in full sunlight and can even have higher yields than shaded coffee, but only when adequately fertilized. However, in full sunlight, coffee trees tend to over-bear, have a shorter productive life span and are more prone to diseases.

On the other hand, shaded coffee will reduce the demand for fertilizer (and productivity), but will ensure that coffee production is more even and that the trees have a longer productive life.

Shade trees also provide other benefits like improvement of soil structure and fertility (especially when nitrogen fixing trees are used) through the increase of organic matter in the soil. Also, the extra layer of trees will reduce the risk of erosion. The micro-climate will improve under shade trees, keeping it cool on hot days and warm on cold nights. Evaporation of water from the soil will be less, which will benefit the trees. Shade trees also reduce the growth of weeds, the branches can be used for mulch or fodder, and the wood can be used for firewood, timber and other useful products.

The practice of utilizing shade trees can be important for every farmer in Guyana who grows trees, either on a commercial basis or for local production, and has a problem with sustaining soil fertility or over-bearing of trees.

However, when there is a shortage of water, one should be careful when planting shade trees, as water competition will increase and some trees may not withstand the water shortage.

STRUCTURE

The shade tree practice always has a structure with at least two layers: a lower layer of cocoa or coffee trees and the second layer of taller shade trees. Sometimes a third and fourth layer are included, such as ground crops and timber trees.

Shade trees are widely spaced in cocoa or coffee plantations, so that the crowns do not quite reach each other (see Figure 25).

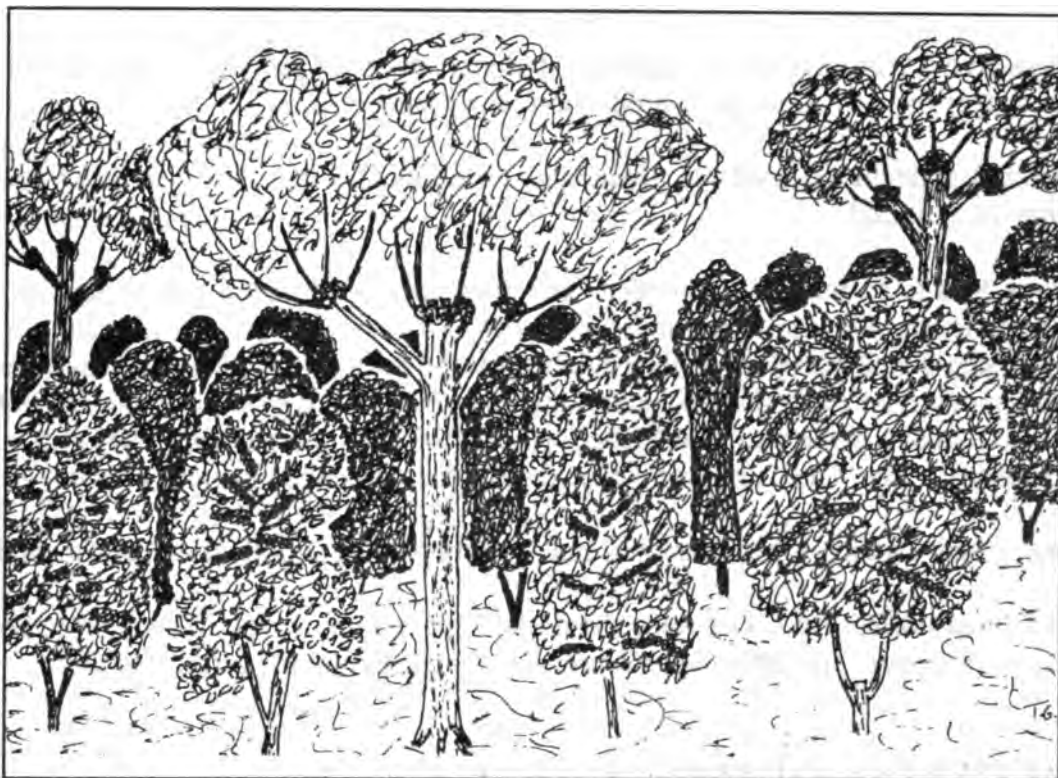


Figure 25: Shade management enhances the coffee production.

ESTABLISHMENT

Different methods can be used for the establishment of shade trees, including direct seeding, planting of seedlings and (depending on the species used) planting of cuttings. Planting of seedlings or cuttings will give you faster establishment of the shade trees. Seedlings can be grown in an on-farm nursery, with a reduction in cost.

Shade trees can be planted either on an existing plantation or at the time a new plantation is started. The shade trees are planted relatively far apart, about 25-35 ft., either in lines or evenly scattered over the field. When a new plantation of coffee or cocoa is planted, they can be planted rather close together, 10-12 ft. apart.

It is also possible to establish shade trees for a new plantation by leaving some trees on the field when clearing it.

MANAGEMENT

Shade trees do not require much management, but it is important that you carry out the activities on time, so that the coffee or cocoa production is not hampered.

If banana and plantain are used for producing shade quickly, then fairly frequent pruning of leaves may be required.

Shade trees need to be regularly pollarded. The main reasons for this are to reduce the amount of shade and to provide the coffee and cocoa with extra nutrients by applying the leaves and twigs as mulch. This is best done at the beginning of the rainy season. Mix the leaves and small twigs with some grass (if available). Add a thick layer of mulch to every other row of coffee or cocoa trees and mix the mulch with the top soil (about 4 inches deep). The other rows are mulched subsequently. This has given better results than mulching all trees at once.

If you notice that shading is becoming too much, additional light pollarding can be carried out.

The soil around coffee and cocoa trees should be kept free of weeds. When coffee/cocoa are planted close together, and after they mature, weeds usually die for lack of sunlight.

CHARACTERISTICS AND EXAMPLES OF TREE SPECIES

The shade trees used should be fully compatible with the coffee or cocoa crop and should compete as little as possible for water and nutrients. They should therefore have the following characteristics:

- preferably nitrogen-fixing, especially on poor soils;
- the root system has to be deep to minimize competition, and good so that the trees will not blow over;
- the crown should be light and spreading above the coffee and cocoa, giving moderate shade;
- the tree should resprout after pollarding;
- preferably able to propagate from large cuttings;
- preferably hornless to permit climbing for pruning.

Examples of tree species are:

- *Acacia mangium*
- *Erythrina poeppigiana*
- *Gliricidia sepium*
- *Leucaena leucocephala*

There are also examples of cocoa grown under a shade of coconut trees. This provides you with useful products but not very much mulch. Banana and plantain can be used to produce shade quickly. These leaves produce good mulch, which helps to control weeds.

CHAPTER FOUR

TREE DESCRIPTIONS



ACACIA MANGIUM

Acacia mangium is one of the many Acacia species found all over the world. They all belong to the Legume family, together with bora, peanut, tamarind, walaba and others.

DESCRIPTION

Acacia mangium is a tall tree, that may grow up to 90 ft., but on less favourable spots may only reach a height of 30 ft. It can make a vigorous, deeply rooted system when growing on deep soils.

Newly germinated seedlings have compound leaves, made up of many leaflets, similar to the leaves of *Leucaena*. These are the true leaves. However, after a few weeks, the Acacia mangium no longer makes these true leaves. Instead, the leaf stalk and main axis of each compound leaf flattens and is so transformed into a phyllode. These phyllodes look like the leaves of common plants. They are simple, parallel veined and very large (4-10 in.). The tree is evergreen.

The flowers of the Acacia mangium are small and white or cream, arranged on a spike up to 4 in. long. As the Acacia mangium is a legume, the fruit is a pod. The young pod is green and straight. As it matures, it becomes blackish brown, and twists and intertwines into irregular spiralled clusters. The seeds in the pod are attached with a bright orange ribbon (funicle). When the pod matures, it bursts open along one of the sides and the seeds hang out on their funicle. After a few days the seeds, including the orange funicle, will fall to the ground. The seeds are black and hard coated, 1/8-1/5 in. long.

Acacia mangium grows best in humid places. Dry periods slow down the growth of the tree. It can grow on eroded, rocky, thin mineral soils and also on deeply weathered soils. Acidic soil conditions are no problem.

Acacia mangium resprouts more slowly after coppicing as the tree becomes older.

PROPAGATION

Acacia mangium is an easy tree to propagate, both through seeding and by cuttings. Seeding is more common.

The seeds are small and light - one pound contains 40,000 to 50,000 seeds. When the seeds are dried and put in an airtight container, they can be kept for several years.



Figure 26: *Acacia mangium* leaves and flowers.

When planting the seeds, it is best to test them first; this treatment is done so that the seeds will germinate faster and at the same time. Bring some water to boil in a pot (about 10 cups water to 1 cup seeds) and remove the pot from the heat. Immediately put the seeds in the hot water. After 30 seconds, pour off the hot water and replace it with cold water and allow the seeds to soak overnight. A healthy set of seeds, with proper treatment, should give a germination rate of 75-80% 8 to 10 days after planting.

The cheapest way to establish *Acacia mangium* is to plant the seeds directly in the soil. The seeds should be planted about 1 inch deep at the beginning of the rainy season. To create a close stand the seeds can be planted 5-10 ft. apart.

It is also possible to grow the seedlings in an on-farm nursery. The seeds can be set directly in bags or first in a seed box. In both instances, the seeds are planted less than 1/2 in. deep. When the plants in the seed box show their first pair of leaflets, they can be transplanted into bags. After 2 to 3 months in the nursery, when the seedlings are 10-12 in. high, they can be transplanted into the field at the beginning of the rainy season.

Another method for propagation is by taking cuttings. Both stem cuttings (from the base of branches) and leafy cuttings (from the top of branches) can be used. Stem cuttings can be planted directly in the field or first in the nursery. The leafy cuttings first have to be set in a propagator.

Under certain land use systems, like trees on pasture, improved fallow and others, natural regeneration is possible.

In the early stages, competition with weeds is a problem. Weeding is therefore necessary up to about 6 months. *Acacia mangium* dies when herbicides are used.

PRODUCTS AND POTENTIAL FOR AGROFORESTRY

Acacia mangium is a very fast growing tree with many uses and is planted throughout the tropics. Useful products are:

- **Fodder:** the leaves can be used for fodder for livestock;
- **Wood:** the wood can be used as fuelwood, pulp, poles and posts, light construction timber, veneer and furniture;
- **Services:** shade, green manure, mulching, nitrogen fixation and soil conservation.

Because of its nitrogen-fixing, deep-rooting system, fast growing and its many uses, *Acacia mangium* is used a lot in agroforestry practices, such as intercropping, improved fallow, windbreaks, firebreaks, shade trees, living fences and trees on pasture.

CASUARINA

The scientific name is *Casuarina equisetifolia*, but in Guyana it is commonly called pine. It is a member of the Casuarinaceae family. Although it is not a member of the legume family, the casuarina is nitrogen-fixing.

DESCRIPTION

Casuarina is a large tree which in humid areas can become 60-120 ft. tall, while in arid areas it only grows 20-40 ft. high. The crown is light and deep as branching starts close to the ground. The ultimate branchlets are slender, green, 10-15 in. long and resemble pine needles. The leaves are very small grey-green and form light toothed rings on the branchlets. The leaves on the main twigs are slightly bigger, and curved back, resembling small thorns. The tree is evergreen.

Casuarina has separate male and female trees. The male flowers are cylindrical spikes (half inch to one-and-a-half inches long) on the branchlets, which fall off when the flowering is over. The female flowers are small reddish heads on a short stalk on the woody branchlets. The seeds are in a small cone-like ball, and will fall out when mature. They are also winged, light brown and about one-quarter inch long.

Casuarina grows best on medium or light sandy soils (not clay) and adapts to moderate poor soils. The tree can survive seasonal water logging and a dry period of 6-8 months maximum. The soils cannot be too acid, but salinity is no problem.

Casuarina can be coppiced, after which it will resprout, but should not be coppiced too often.

PROPAGATION

Casuarina can be propagated by seeds and by cuttings.

The seeds are small and very light. One pound contains 200,000 to 250,000 seeds. When they are stored in an airtight bag in a refrigerator, they can be kept for one year or more.

The seeds do not need any treatment before planting. A healthy set of seeds should give a germination rate of 70-80%, 30 to 40 days after planting.

The cheapest way to establish the Casuarina is to plant the seeds directly in the soil. The seeds should be planted about 1 in. deep at the beginning of the rainy season in individual holes.

It is also possible to grow seedlings in an on-farm nursery. The seeds can be set directly in bags or first in a seed box. In both cases, the seeds are planted less than ½ in. deep. Germination will start after 4 to 10 days. When the plants in the seed box are about 4 inches high, after 4 to 6 weeks, they can be transplanted into bags. In the nursery, the seedlings need to be placed in the shade. When the seedlings are 6 to 12 months old, they can be planted into the field.

Another method for propagation is by taking cuttings. Stem cuttings (from the base of branches) can be used. The cuttings can be planted directly in the field or first in the nursery.

Under certain agroforestry practices, like trees on pasture, improved fallow, and others, natural regeneration is also a possibility.

Young casuarina is not able to compete with weeds. Weeding is therefore necessary in the nursery and especially in the field, until the seedlings are tall enough.

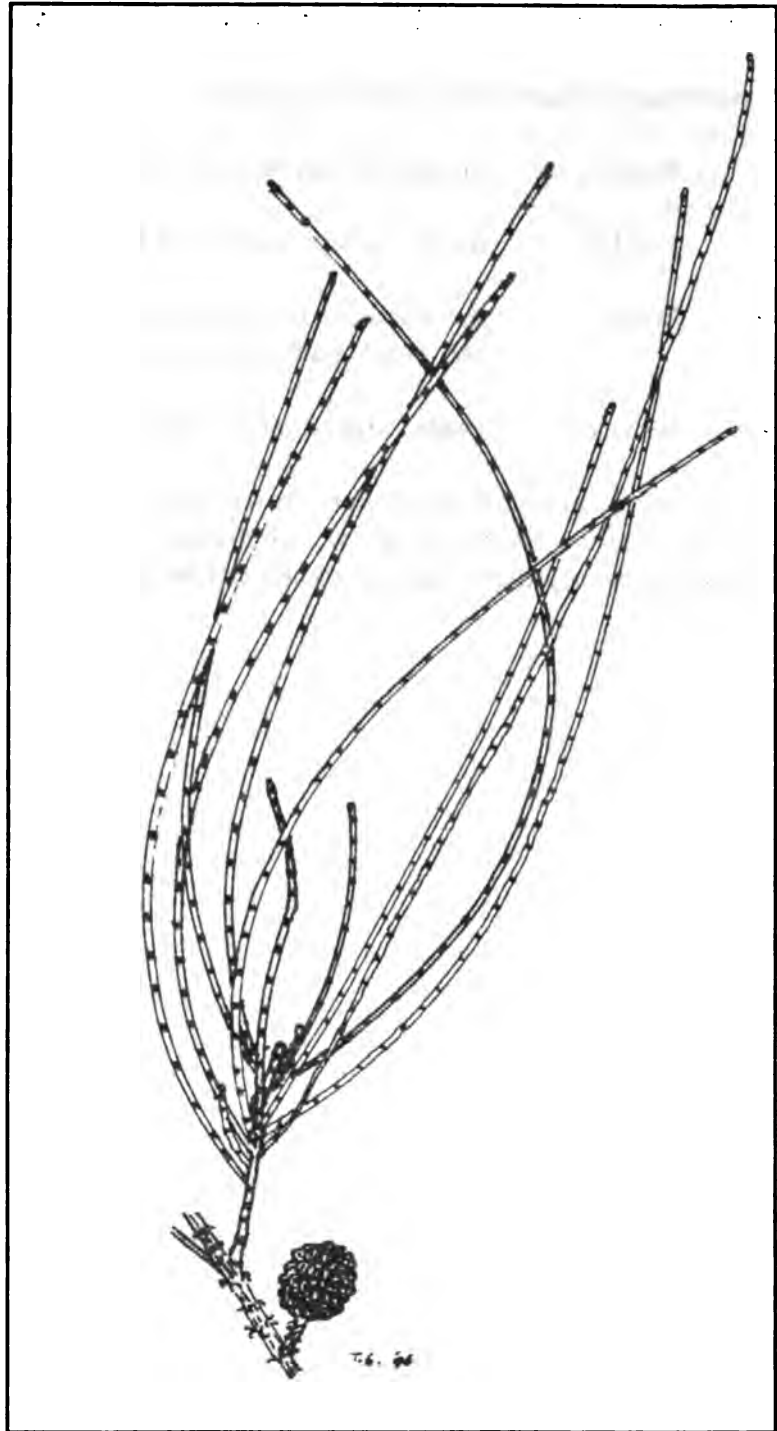


Figure 27: *Casuarina equisetifolia* leaves and fruit.

PRODUCTS AND SERVICES, POTENTIAL FOR AGROFORESTRY

Casuarina produces several useful products:

- **Food:** oil and fat can be extracted from the seeds;
- **Fodder:** the flowers provide good bee-forage;
- **Wood:** the wood can be used for fuelwood and charcoal (very high quality), poles and posts, pulp, heavy construction timber and veneer;
- **Services:** shade, green manure, nitrogen fixation and soil conservation.

Because of its nitrogen fixing, light crown and many uses, Casuarina can be used in agroforestry systems such as improved fallow, windbreaks and living fences. As water competition with Casuarina is very high, the tree should not be used in combination with food crops.

ERYTHRINA

The scientific name of ERYTHRINA is *Erythrina poeppigiana*. In Guyana, the tree is more commonly known as cork-wood, orrinoc plant, cocoa-mama or coffee-mama. The tree is a member of the legume family together with bora, peanut, tamarind, wallaba and others. The Erythrina is native to South America, and is widely planted in other tropical parts of the world.

DESCRIPTION

Erythrina is a large tree that can grow up to 65 ft. high and has some stout spines. The compound leaves are formed out of 3 oval leaflets, which are short pointed at the end and nearly straight at the base. The leaves are 8-12 in. long, including the light green, finely hairy stalk. The tree loses its leaves early in the dry season.

Erythrina flowers when the tree is leafless. The flowers are about 2 inches long, orange-red and many of them grow on a long stalk (4-8 in.). The flowers fall soon after opening, colouring the ground under the tree orange-red too. Because Erythrina is a legume, the fruit is a pod. These pods grow while the tree is leafless and are 5-10 in. long and 1/2 in. wide. It takes about two months for the pods to mature, after which the pods will burst open and many kidney-shaped, bean-like seeds fall out. The seeds are poisonous.

Erythrina grows best on well-drained light soils of any type. It can grow on both wet and dry soils.

Erythrina coppices well. This means that after coppicing or pruning, it will resprout quickly.

PROPAGATION

Erythrina can be propagated both from seeds and from cuttings.

It is not known for this species how many seeds are in one pound, how they can best be stored and for how long, how they can best be treated or what the germination rate is. It is therefore best to do a germination test always before starting to propagate this tree.

The cheapest way to establish the Erythrina is to plant the seeds directly in the soil. The seeds should be planted at a depth of about twice the diameter of the seeds at the beginning of the rainy season. When the seeds are planted close together in lines, deep furrows can be made in which to plant the seeds. When wider and more randomly spaced, individual planting holes can be made.

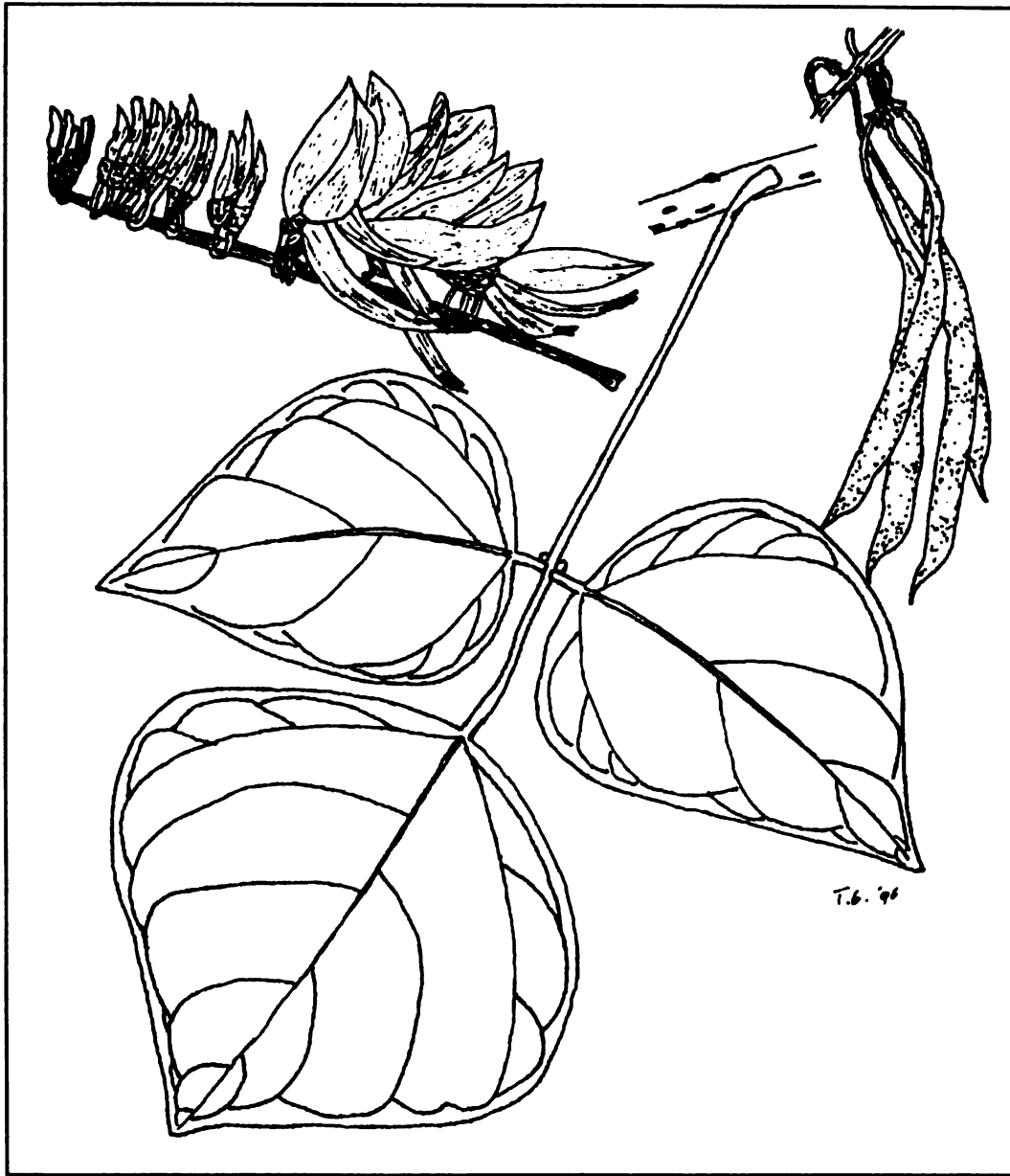


Figure 28: *Erythrina poeppigiana* leaf, flowers and fruits.

It is also possible to grow seedlings in an on-farm nursery. You will have to do a seed test first. Then seeds can be set directly in bags or first in a seed box. In both instances, the seeds are planted less than $\frac{1}{2}$ in. deep. When the plants in the seed box have developed their first real leaf, they can be transplanted into bags. After 2 to 3 months in the nursery, the seedlings can be planted in the field.

Another method of propagation is by taking cuttings. Both stem cuttings (from the base of branches) and leafy cuttings (from the top of branches) can be used. Stem cuttings can be planted directly in the field or first in the nursery. The leafy cuttings first have to be set in a propagator.

Under certain land-use systems, like trees on pasture, improved fallow, and others, natural regeneration is also a possibility.

PRODUCTS AND POTENTIAL FOR AGROFORESTRY

Useful products from the Erythrina are:

- **Food:** flowers can be used in salads and soups;
- **Fodder:** leaves can be used for fodder;
- **Wood:** wood can be used as fuelwood, farm implements and general utensils, poles and posts, and pulp;
- **Services:** shade, green manure, mulching, nitrogen fixation and soil conservation.

Because of its nitrogen-fixing, deep-rooting system, fast resprouting and many uses, Erythrina is used in many agroforestry practices, like intercropping, alley cropping, improved fallow, shade trees, living fences and trees on pasture.

GLIRICIDIA

The scientific name of Gliricidia is *Gliricidia sepium* but in Guyana it is known as quick-stick. It is a member of the legume family together with bora, peanut, tamarind and wallaba, to name but a few.

DESCRIPTION

Gliricidias can become about 40 to 50 ft. tall, without spikes or thorns. It roots deeply, if grown from seed with one taproot and if grown from a cutting with several taproots. It has few shallow lateral roots. Generally the crown is irregular and open and has thin leaves. The tree loses its leaves in the dry season.

The flowers of Gliricidia grow with many together on a flower stalk, along old branches when leafless, or on the back of the leaves. The flower stalk is about 2-5 in. long and unbranched. The flowers are whitish-pink or purplish, less than 1 in. long, and grow on slender stalks on the flower stalk. Because Gliricidia is a legume, the fruit is a pod. These pods are 4 to 6 in. long, oblong, narrow, flat and short-stalked. They are yellow-green when young and turn blackish when mature. When they are mature, they split open at both edges and 3-8 seeds are dropped. The seeds are shiny-blackish, beanlike and one-third to half an inch long.

Gliricidia grows on every soil type. The texture can be light sand to heavy clay, dry or moist, drained or seasonal water-logged, acid or alkaline, poor or fertile.

Gliricidia coppices well. This means that after coppicing or pruning, it will resprout quickly.

PROPAGATION

Gliricidia is a very easy tree to propagate, both through seeding and by cuttings. Trees grown from seeds make a deeper and stronger root system and are better adapted to grazing by sheep.

One pound contains about 3,000 seeds. When you store the seeds in a cool and dry place, you can keep them up to six months. When stored in a refrigerator, they can be kept for one year.

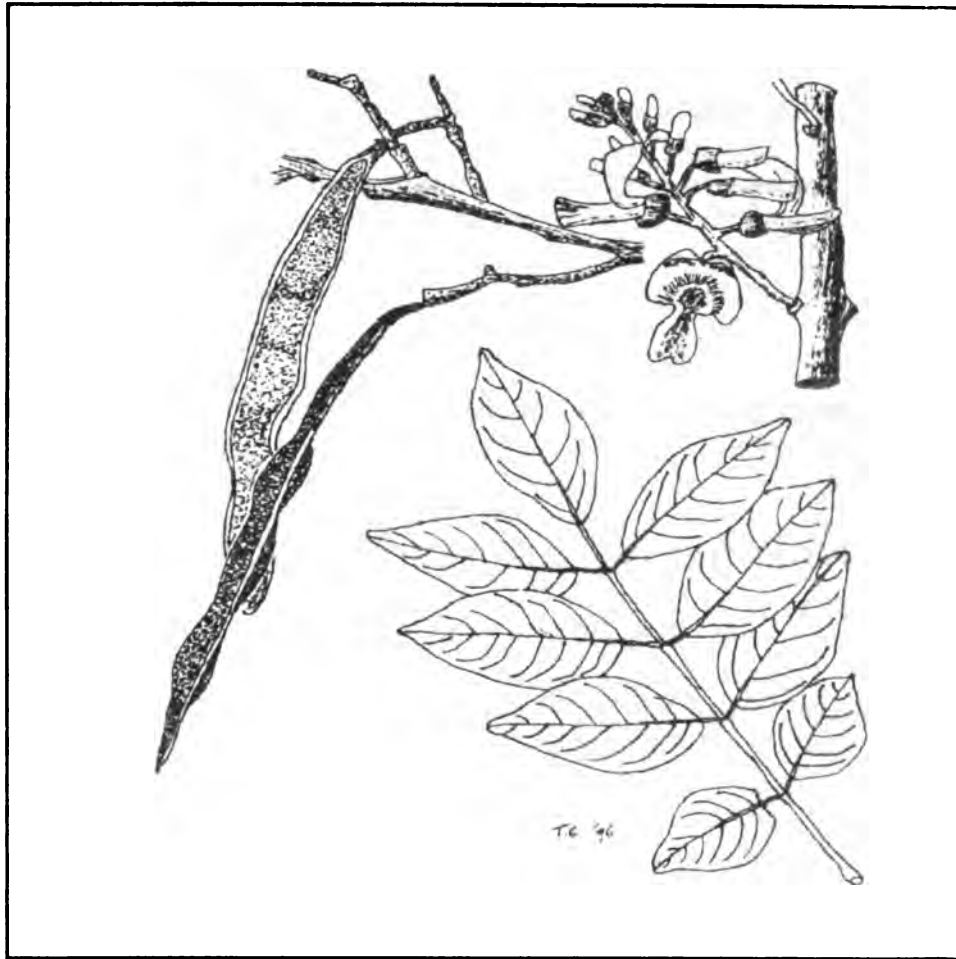


Figure 29: *Gliricidia sepium* leaf, flowers and fruits.

When planting the seeds, it is best to treat them first. This treatment is done so that the seeds will germinate faster and all more or less at the same time. Place the seeds in a pot with a lot of cold water. Use 5 cans of water for 1 can of seeds. Remove any seeds that float to the top. Let the seeds soak for 1 to 2 days, changing the water every 12 hours. After this, immediately plant all the swollen seeds. A healthy set of seeds, with proper treatment, should give a germination rate of 90%, 3 to 5 days after planting.

The cheapest way to establish *Gliricidia* is to plant the seeds directly in the soil. The seeds should be planted about 2 in. deep at the beginning of the rainy season. When the seeds are planted close together in lines, deep furrows can be made in which to plant the seeds. When more widely and more randomly spaced, individual planting holes can be made.

It is also possible to grow seedlings in an on-farm nursery. The seeds can be set directly in bags or first in a seed box. In both instances, the seeds are planted less than ½ in. deep. When the plants in the seed box have developed their first real leaf, they can be transplanted into bags. After 2 to 3 months in the nursery, the seedlings can be planted in the field.

Another method for propagation is by taking cuttings. Both stem cuttings (from the base of branches) and leafy cuttings (from the top of branches) can be used. Stem cuttings can be planted directly in the field or first in the nursery. The leafy cuttings first have to be set in a propagator. Gliricidia earns the name 'quick-stick' by the fact that it establishes itself quickly through cuttings.

Under certain agroforestry practices, like trees on pasture, improved fallow, and others, natural regeneration is also a possibility.

PRODUCTS AND POTENTIAL FOR AGROFORESTRY

Gliricidia is very fast growing and produces a variety of useful products:

- **Food:** the flowers can be eaten as a vegetable, the fruits are edible and oils and fats can be extracted;
- **Fodder:** the leaves, and seed shoots are a valuable fodder for cattle, but are toxic to horses and most other animals;
the flowers provide good bee-forage;
- **Wood:** the wood can be used for fuelwood, charcoal, farm implements, poles and posts, heavy construction timber, furniture and tool handles;
- **Others:** the seeds, bark, leaves and roots can be used to make natural insecticides;
- **Services:** shade, green manure, mulching, nitrogen fixation, soil conservation and an allelopathic effect on weeds. This means that weeds do not grow very well under this tree due to the chemicals in the tree.

The beneficial structure of Gliricidia and its many products and services make the tree very useful in agroforestry practices, like intercropping, alley cropping, improved fallow, shade trees, windbreaks, fire breaks, living fences and trees on pasture.

LEUCAENA

The scientific name of *Leucaena* is *Leucaena leucocephala*, but in various English-speaking countries, it is known under one of the following names: leadtrees, wild tamarind, white popinac, jumbiebean, tantan and horse-tamarind. It is a member of the legume family, together with bora, peanut, tamarind and wallaba.

DESCRIPTION

Leucaena is a slender tree 30 to 60 ft tall, without spikes or thorns. It roots deeply, has a taproot and few shallow lateral roots. Different varieties of this species either form a straight trunked tree, branch close to the ground or form a more bushy tree. Generally, the crown is broad and open and has fine leaves. In dry areas (Rupununi), the tree loses its leaves in the dry season but in more humid climates, it is evergreen.

Leucaena normally flowers and fruits throughout the year with very small white flowers arranged in round heads of less than an inch in diameter. Because *Leucaena* is a legume, the fruit is a pod. These pods are 4 to 8 in. long, oblong, narrow and flat. When they are mature they split open at both edges and 12-25 seeds are dropped. The seeds are glossy brown, flat and about a quarter of an inch long and about one-eighth of an inch wide.

Leucaena grows best in deep, well-drained soils that are not too acid. It is well adapted to a wide variety of soil textures and grows on both fertile and infertile soils.

Leucaena coppices well. This means that after coppicing or pruning it will resprout quickly. *Leucaena* can be pruned at intervals of 2-4 months.

PROPAGATION

Leucaena is a very easy tree to propagate, both through seeding and by cuttings. Seeding is most common.

The seeds are small and light, one pound containing about 10,000 to 18,000 seeds. When you store the seeds in a cool, dry place, you can keep them up to three years.

Before planting the seeds, it is best to treat them. This treatment is done so that the seeds will germinate faster and all, more or less, at the same time. Bring some water to boil in a pot and then remove the pot from the heat. Soak the seeds for 2-3 min. in the hot water. Replace the hot water with cold water. Leave them to soak in the cold water over night for up to 3 days. A healthy set of seeds, with proper treatment, should give a germination rate of 80%, 8 to 10 days after planting.

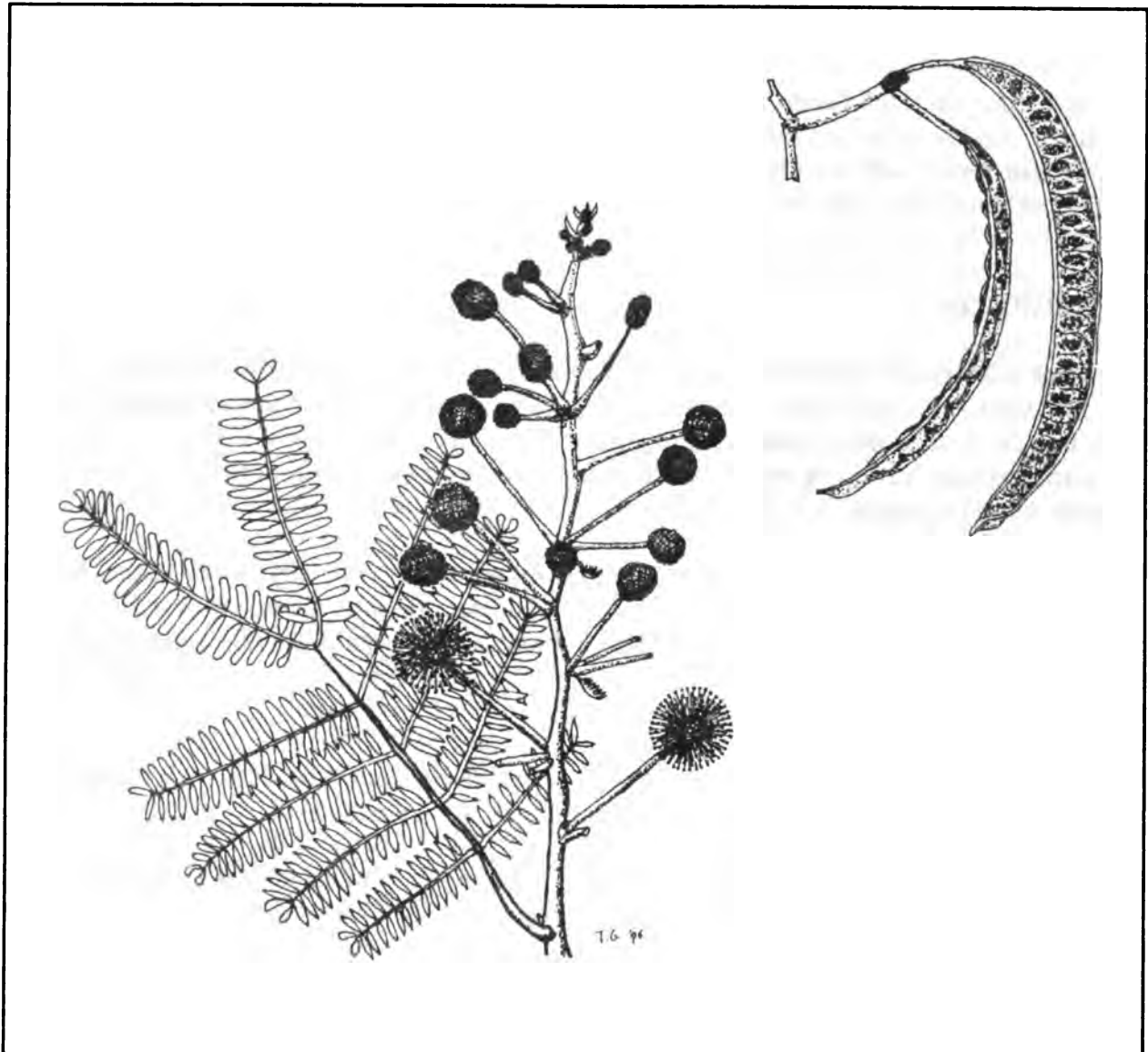


Figure 30: *Leucaena leucocephala* leaf, flowers and fruits.

The cheapest way to establish the *Leucaena* is to plant the seeds directly in the soil. The seeds should be planted about 2 in. deep at the beginning of the rainy season. When they are planted close together in lines, deep furrows can be made in which to plant them. When more widely and more randomly spaced, individual planting holes can be made.

It is also possible to grow seedlings in an on-farm nursery. The seeds can be set directly in bags or first in a seed box. In both instances, the seeds are planted less than ½ in. deep. When the plants in the seed box have developed their first real leaf, they can be transplanted into bags. After 2 to 3 months in the nursery, the seedlings can be planted in the field.

Another method of propagation is by taking cuttings. Both stem cuttings (from the base of branches) and leafy cuttings (from the top of branches) can be used. Stem cuttings can be planted directly in the field or first in the nursery. The leafy cuttings first have to be set in a propagator.

Under certain agroforestry practices, like trees on pasture, improved fallow, and others, natural regeneration is also a possibility.

Leucaena grows slowly when it is young, and competition with weeds can be a problem. Weeding is therefore necessary in the nursery and especially in the field, until the seedlings are about 6 months old, when they will start to grow fast.

PRODUCTS AND POTENTIAL FOR AGROFORESTRY

Leucaena is one of the fastest-growing trees known and because of that and its many uses, it has been planted throughout the tropics. Useful products are:

- **Food:** the young pods are used as a vegetable and the seeds can be used as bush coffee;
- **Fodder:** the leaves, pods and seeds are a very valuable fodder, but when eaten solely for long periods, they can be poisonous to horses, donkeys, mules hogs and rabbits. Variety is therefore very important;

the flowers yield good bee-forage;
- **Wood:** the wood can be used for fuelwood, charcoal, poles and posts, light construction timber, utensils and furniture;
- **Services:** shade, green manure, mulching, nitrogen fixation and soil conservation.

Because of its nitrogen fixing, light crown, deep-rooting system, fast-growing, fast-resprouting after pruning and many uses, Leucaena is an excellent species to use in many agroforestry practices like intercropping, alley cropping, trees on pasture, shade trees, windbreaks and living fences.

NEEM

The scientific name of Neem is *Azadirachta indica*. It is a member of the Meliaceae family.

DESCRIPTION

Neem is a medium-sized tree which grows maximally 75 ft. tall, with a quite dense, round crown. The root system penetrates deeply and establishes fast. The first branches start low, at 6-12 ft. height. The leaves are crowded near the end of the twigs. The compound leaves are tall and comprise 9-17 small leaflets. The tree is usually evergreen, but can drop its leaves in extremely dry periods.

Neem normally flowers at the end of the dry season. The flowers are small, white, yellow or cream colored and smell sweet. They grow on a stalk about 8 in. long. The fruits are about 1/2 - 3/4 in. long and elliptical and have one large seed. At first they are light yellow and turn purple when mature. The fruit takes about 2 months to mature.

Neem grows best in deep, well-drained soils. It grows on all types of soils with a light or heavy texture and even grows on sites with poor fertility. Neem grows on soils that are slightly acid and will make the soil surface neutral with its leaf litter.

Neem can be coppiced, but not too often and only after being well established

PROPAGATION

Propagation can be done both through cuttings and through seeding. Seeding is most common.

The seeds are quite long and one pound contains about 2,000 seeds. They cannot be stored. They are short-lived and lose their viability in 2 to 4 weeks' time, therefore, the seeds should be used immediately.

When planting the seeds, it is best to treat them first. This treatment is done so that the seeds will germinate faster and close to the same time. Place the seeds in a pot with a lot of cold water. Use 5 cans of water to 1 can of seeds. Remove any seeds that are floating to the top. Let the seeds soak for 1 to 2 days, changing the water every 12 hours. After this, you immediately plant the swollen seeds. A healthy set of seeds, with proper treatment, should give a germination rate of 75%, rapid and uniform, 10 to 12 days after planting.

The cheapest way to establish Neem is to plant the seeds directly in the soil. The seeds should be planted one to one and a half inches deep at the beginning of the rainy season.

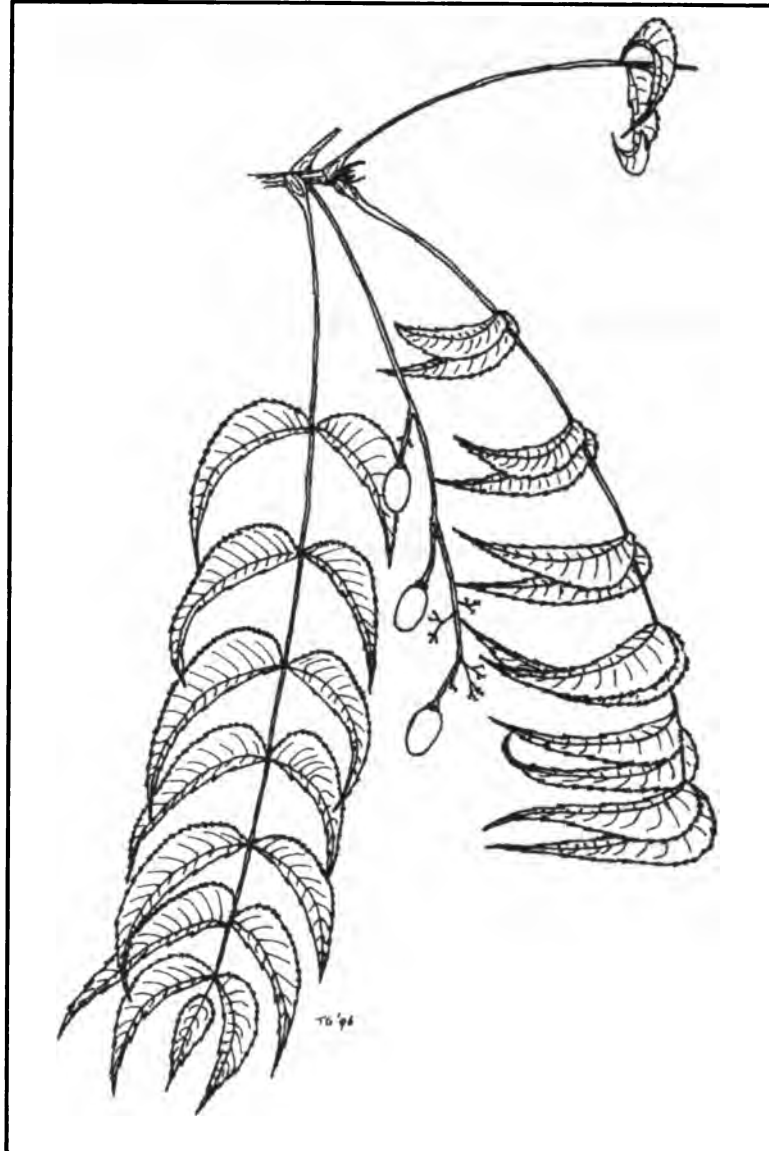


Figure 31: Neem, *Azadirachta indica*, leaves and fruits.

It is also possible to grow seedlings in an on-farm nursery. The seeds can be set directly in bags or first in a seed box. In both cases, the seeds are planted about 1 in. deep. When planted directly in the bags, 2-4 seeds per bag are planted. After germination, make sure that every bag contains one seedling; the others can be transplanted into other bags. When the plants in the seed box develop their first set of leaves, they can be transplanted into bags. The seedlings in the nursery need slight shading. After 11 to 14 weeks, the seedlings can be planted in the field.

Another method of propagation is by taking cuttings. Both stem cuttings (from the base of the branches) and leafy cuttings (from the top of the branches) can be used. Stem cuttings can be planted directly in the field or first in the nursery. The leafy cuttings first have to be set in a propagator.

Under certain land-use systems, like trees on pasture, improved fallow, and others, natural regeneration is also a possibility.

PRODUCTS AND POTENTIAL FOR AGROFORESTRY

Neem is a very useful tree grown throughout the world. Useful products are:

- **Food:** both the fruits and the leaves can be eaten;
- **Fodder:** leaves can be used as fodder;
flowers produce good bee-forage;
- **Wood:** the wood can be used as fuelwood, poles and posts, light construction timber and furniture;
- **Others:** there are many possibilities for making insecticides out of the leaves and the seeds. This is what the tree is most famous for;
lamp oil and soaps can be made from the seeds;
bark, leaves, fruits and oil are medicinal;
- **Services:** shade, green manure, mulching and soil conservation.

Neem is mostly used in intercropping, living fences, windbreaks and multiple-purpose trees on farmland. It is such a useful tree, especially its many ways to make natural insecticides, that it is always useful to have a few Neem trees on your farm or around your house.

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