

#### **ACKNOWLEDGEMENTS**

This book and the other books in this series are dedicated to Nguyen My Hanh, a dear friend whose passion, devotion, and love for humanity have inspired every page.

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### Introduction



Photo above: Forest of Song Thanh Nature Reserve, Quang Nam Vietnam

Inset Photos: Cat Ba Langur Saola

uman existence is inextricably linked to the environment. Throughout the world, people depend on the exploitation of natural resources. However, circumstances such as extreme poverty can force individuals to over exploit these resources in order to survive. This creates a paradox: To ensure their immediate survival, humans are using natural resources at a rate that jeopardizes their future survival. The very resources upon which human lives depend are being exploited at an unsustainable rate. Future unavailability of key resources will lead to further human poverty and to loss of the very natural resource heritage that provides us with life and nurtures our spirits. It is evident that if over exploitation of natural resources persists at the present rate, an environmental crisis will lead directly to a human crisis.

The forests of Vietnam provide sanctuary for an amazing range of floral and faunal species. Rare and endangered species such as the Saola (*Pseudoryx nghetinhensis*) can be found there. Additionally, seven pheasant species, including the endemic Edwards Pheasant (*Lophura edwardsi*), which was thought to be extinct, and the Crested Argus (*Rheinardia ocellata*), which is also endemic to the region, are found in these forests. The forests of Vietnam are also home to many rare primates, including gibbons (*Hylobates sp.*) and three species of Douc Langur (*Pygathrix sp.*). At least six species of primate, including the Cat Ba Langur (*Trachypithecus poliocephalus*), the Delacours Langur (*Trachypithecus delacouri*), and the Tonkin Snub Nosed Monkey (*Pygathrix avunculus*), are endemic.

Numerous other highly threatened fauna, including wild cattle such as the Gaur (*Bos gaurus*), the Javan Rhinoceros (*Rhinoceros sondiacus annamiticus*), the Indochinese Tiger (Panthera tigris corbetti), the Asiatic Black Bear (*Ursus thibetanus*), the loris (*Nycticebus spp.*) and the Asian Wild Dog (*Cuon alpinus*), are found in these forests.

However, this rich and unique biodiversity is declining rapidly. This is partly due to the fact that the country is heavily dependent upon natural resources, with agriculture, forestry and fisheries accounting for more than 80 per cent of total employment in the country. A fast growing population further exacerbates the pressure on the environment. At the 1999 annual growth rate of 2 per cent, the country's population of 77 million will double every 34 years. In the uplands, population pressure is rendering traditional agricultural systems unsustainable, and the traditional rotation/fallow period has, in some places, been shortened by two-thirds. The shorter fallow period exhausts the land more quickly and requires more forest to be cleared to create new, productive fields. The high levels of deforestation and intensive cropping practices lead to soil erosion, lowland flooding, and soil infertility, all of which increase the insecurity of food supplies. Illegal trade in wildlife, unsustainable hunting and fishing, and the collection of non-timber forest products also contribute to the degradation of the ecosystem, even though these activities supplement incomes.

Long-term conservation of the natural world cannot be achieved unless each individual takes responsibility for protecting it. In most cases this requires a change in behaviour. In order to change their behaviour and participate in conservation, individuals need three things. First of all, they need to see and acknowledge the problems they and their environment are facing. Secondly, they need to realize the benefits of changing their behaviour and the consequences of a failure to change. And thirdly, they need to have an alternative to behaviour that negatively affects the environment, and this alternative needs to provide them with benefits comparable to those that they currently receive.

Potentially, agroforestry can target the current threats to the environment while meeting the human needs of rural communities. For farmers currently using swidden agriculture, agro-

forestry technologies such as contour hedgerows, improved fallow and alley cropping offer increased soil fertility and better soil and water conservation. These techniques improve crop yields and food security while limiting the need to abandon old fields and cut forest in search of more productive ones.





Illegal timber extraction from the forests is a common way to increase incomes and meet domestic demands for wood; woodlots on the farm can provide an alternative to this practice. Communities collect non-timber forest products (NTFP's) from the forest to supplement their incomes and diets.

Establishing agroforestry systems such as multi-storied home gardens, with species that are valued for domestic use and for sale in domestic and international markets as well as for soil protection and soil regeneration, offer a good alternative to harvesting from natural forests. Furthermore, hunting is a common practice to increase incomes and to supplement diets; income from the sale of different agroforest products can both increase household incomes and enhance local diets thus reducing the need for subsistence hunting.

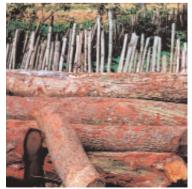
This training guide equips the extension officer with a comprehensive set of tools with which to train others in agroforestry practices. It has two goals. One goal is to help extension officers work with communities in action-oriented environmental education programmes. The other goal is to provide communities with the skills required for practising livelihoods that have a benign, or ideally, a beneficial, impact on the natural world.

The guide has three sections: I. The Tree Nursery; II. Agroforestry Technologies; and III. Agroforestry Species. Technical information with easy to understand illustrations and photos on how to establish agroforestry systems that contribute to the livelihoods of communities living in and around protected forest areas while conserving natural resources are provided in these sections.

This book is one of a series developed by the Environmental Education Programme of WWF Indochina in conjunction with the Forest Protection Departments of Quang Nam, Thua Thien Hue, and Kon Tom provinces. Three other books are included in this series: Environmental Education: A Training Guide for Practitioners; Discovering Nature: An Activity Guide for School Children; and Monitoring and Evaluation for Community Based Environmental Education Programmes. The books provide governments, non-government organizations, and donors with alternatives for conservation that can be integrated into environmental plans and policies.







#### S E C T I O N O N E

## The Tree Mursery



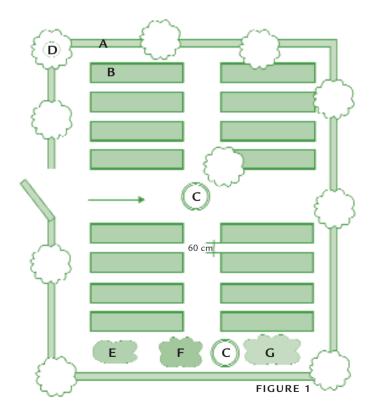
Photo above: Example of a living fence used in a nursery Inset Photo:

Leguminous shrub used for fodder

urseries are essential for anyone interested in establishing agroforestry systems. They are the starting point for the tree that will take on a life in the field. Farmers can use nurseries to propagate seedlings either by vegetative methods or by seed. Careful planning and design of a nursery is important if high quality seedlings that will yield the best results in the field are to be raised. This section provides the necessary technical information to establish such a productive and healthy nursery.

#### **NURSERY LAYOUT**

The letters, A - G, pictured in this diagram correspond to the letters in Figure 2



#### 1.1 SITE SELECTION

The first and most important step in building a successful nursery is to find a suitable site for it. There are various criteria to keep in mind when selecting this site. (*See figures 1 and 2 for example of nursery layout*) It should:

- be close to a stream or near a readily accessible source of water such as a well
  - be in an area that is easily accessible and convenient to get to (such as close to the house or the farm)
  - have good soil, sand and compost or manure, or be convenient to a source of these things
  - be reasonably flat or terraced (a large slope will make it difficult for the seedlings to stand upright and will be prone to water flow that can destroy the seedlings)
  - be large enough to accommodate the plants (roughly 10m x 10m for every 5,000 plants), and to provide areas for working, for seedbeds, and for storage of soil and organic material
  - A have shade in the work area to protect both workers and plants
  - A have a fence, ideally a living fence and be located in an area that is protected from strong winds.

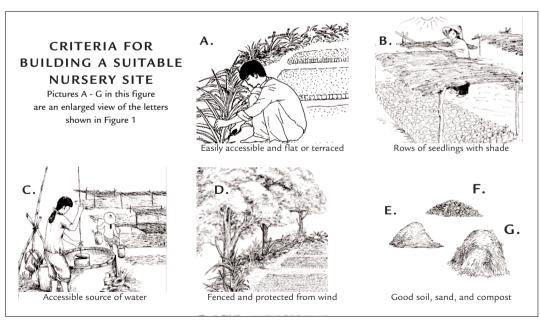
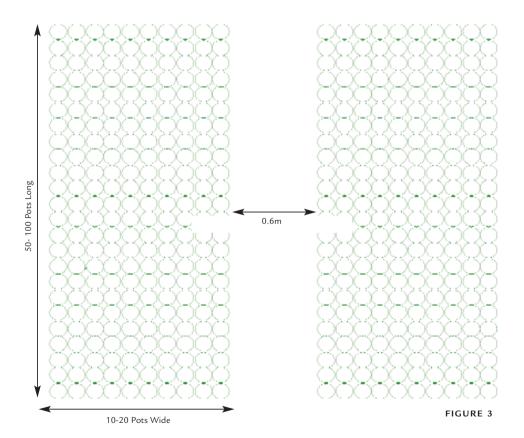


FIGURE 2

#### 1.2 Nursery Layout and Preparation

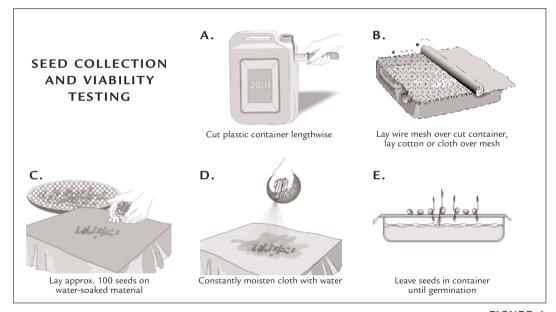
Once the site has been selected, clear away any stumps, roots or large stones that might interfere with the location of the seedlings. If the site has a steep slope (greater than ten degrees), level or terrace it. Make terraces at least 5m wide to allow enough space for seedlings or seedbeds. To prevent erosion and runoff, plant binding grasses on terrace edges. Once this is done it is important to build a fence around the nursery to keep out strangers and animals and to provide some shade. Plan the layout of the nursery so that there is a suitable place for seedbeds, potted seedlings, soil, sand, compost or manure, and a work area with shade. Construct seedbeds as in figure 10. As a general guide, make seedbeds about 80-100cm wide so that you can reach all the seedlings when weeding and watering. Make walkways between rows of potted seedlings wide enough for comfortable access. To facilitate counting and to provide for better management, arrange pots in even numbers (for example, in groups of 10 or 20 pots wide and 50 or 100 pots long). (See figure 3) If possible, orient the rows of plants lengthwise east to west so that all plants in the rows receive uniform amounts of light.



<sup>-</sup> THE AGROFORESTRY FIELD GUIDE: A TOOL FOR COMMUNITY BASED ENVIRONMENTAL EDUCATION -

#### 1.3 SEED COLLECTION AND VIABILITY TESTING

After the site is selected and prepared the next step is to collect or buy the seed of the desired tree species to be planted. When fruit is ripe, collect seeds from at least 30 mature, healthy, vigorous trees. Store seeds in a cool, dry place to avoid loss of viability. Remember that some seeds can be stored for much longer than others and some cannot be stored at all. To check seed viability, carry out the following simple test. (*See figure 4*) Cut a rectangular plastic container lengthwise so that the closed face lies flat on a table. Lay wire mesh over the open face of the container, and lay cotton or cloth on the mesh. Soak the cloth or cotton with water and lay about 100 seeds on the material. Keep the cloth constantly wet by spraying it with water when necessary so that the seeds remain moist. Leave the seeds like this until they begin to germinate. Count how many seeds germinate. If you laid 100 seeds on the germination tray and only 25 germinated, the germination rate is about 25 per cent. In this case, plant four seeds in each pot.



#### 1.4 CALCULATING THE SEED REQUIREMENT

FIGURE 4

To calculate seed requirements a farmer should know the number and species of trees needed, the size of the area to be planted and the desired spacing between the trees. Farmers should also know how many seeds there are in 1kg for the particular species being planted, and the germination rate of that species. Conducting the test above (*refer to section 1.3*) can establish the germination rate. Let's look at an example and calculate the amount of seed required. A farmer wants to plant a green manure bank measuring 1,000m x 500m with Gliricida sepium.

All the trees must be at least 2m apart. That is, the spacing is to be  $2m \times 2m$ . G. sepium has 7,000 seeds per kilogram. The seed the farmer wants to use has a 70 per cent germination rate. Note that the amount of seeds required will depend on the number of seedlings to be planted out and that this will partly depend on the shape of the block of land and whether or not trees can be planted right on the boundaries of the land. In most cases, the calculation will be close to accurate if you divide the total area of land (in this case, 1,000m  $\times$  500m, or 500,000m²) by the amount of space needed by each tree (in this case  $2m\times 2m$ , or  $4m^2$ ).

```
Area = 1,000 x 500m = 500,000 m² Spacing = 2m \times 2m = 4m^2 Seedlings needed = Area/Spacing = 500,000m2/4m^2 = 125,000 Additional seeds needed to make up for the 30\% of seeds that will not germinate = 30\% \times 125,000 = 37,500 Total number of seeds needed = 125,000 + 37,500 = 162,500 As there are 7,000 G. sepium seeds per kilogram, the required 162,500 seeds will weigh 162,500/7,000kg = 23.21kg Therefore, a total of 23.21 kg of seeds is required for the area to be planted.
```

#### 1.5 SEED TREATMENT

To improve and speed up germination rates, use one of the four treatments described below. (*See figure 5 for more details on water treatment methods*) After treatment, plant the seeds immediately.

- 1. **Cold water treatment:** Place seeds in a cloth or sock and immerse in cold water for 12-48 hours.
- 2. **Hot water treatment:** Boil water in a pot and remove from the heat for 10 to 15 minutes. Place the seed in a cloth or sock and soak in the water for up to two days.
- 3. Boiling water treatment: Boil water in a pot and remove from the heat. Put the seed in a cloth or sock and place in the water for two minutes. Pour out the hot water and replace with cold water. Leave the seeds immersed for up to two days.
- 4. **Scarification**: Use sandpaper to scarify the end of the seed coat where the root will emerge. (Generally, this end has an indentation.) Be careful not to damage the seed itself.



FIGURE 5

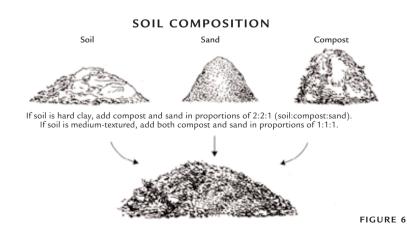
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#### 1.6 Soil and Organic Material Preparation

Plant growth is highly dependent on the texture and nutrient content of the soil. Soil texture can range from sticky clay to gritty sand. Sticky clay is not good for drainage and aeration. Sandy soil does not retain enough water and nutrients for optimal plant growth. The best soil for most seedlings is neither sticky nor sandy but somewhere in between, allowing for retention of water, good drainage and aeration. (*See figure 7*)To get such texture, it may be necessary to adjust the soil content. If the soil is hard clay, add compost and sand in proportions of 2:2:1 (soil:compost:sand). If the soil is medium-textured, add both compost and sand in proportions of 1:1:1. If the soil is sandy, add only compost at a ratio of 1:1. (*See figure 6*)

Organic material in soil provides the nutrients essential for good plant growth. The two most common sources of organic material for use in the nursery are compost and animal manure.



- SECTION ONE: THE TREE NURSERY -

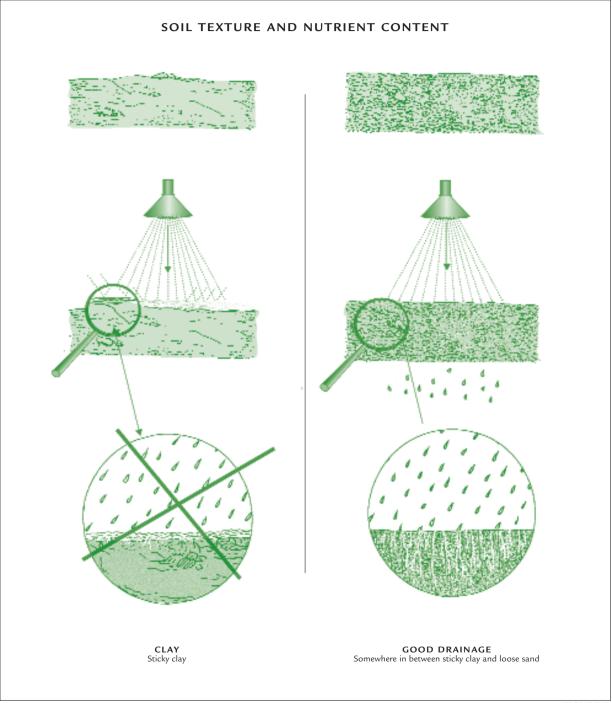


FIGURE 7

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#### 1.7 How To Make Compost

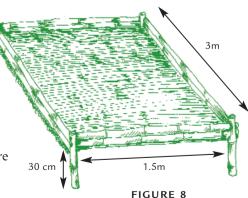
Compost is the name given to organic matter (such as vegetables, fruit, leaves and grass) that has been broken down by bacteria, insects and fungi into a nutrient-rich material. Compost can be used by plants as fertilizer. The process of making compost can take from 40 days to four months.

To make compost, gather a number of different organic materials, such as grass, fruit skins, vegetable matter, sugar cane, corn or rice husks, weeds, or leaves from leguminous plants such as Leucaena leucocephala or Tephrosia candida. Break or chop the material into small pieces (1–2cm). Put the pieces in a pile. Pour water on the pile (the microorganisms that are working on the pile of organic waste and turning it into compost rely on water and oxygen to survive). Turn the pile every few days and sprinkle it with water every so often to keep it from drying out. It should remain moist but not soaked. Over watering it can kill the microorganisms. The content of the pile should be about 50 per cent water. When you squeeze a clump with your hand, it should feel wet but water shouldn't drip out.

There are two types of microorganisms that digest the organic material both of which raise the temperature of the pile. The first type raises the temperature to 50 degrees centigrade. After this, the temperature will autonomously increase to 65 degrees centigrade, at which point the first organisms will die off and organisms adapted to high heat will take over and continue to break down the materials. These temperature-tolerant organisms will raise the temperature to a peak of 70 degrees centigrade. The longer the temperature stays at 55-65 degrees centigrade, the faster the compost will be made.

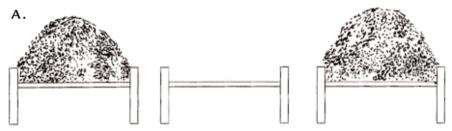
One system for making compost that is recommended by the World Agroforestry Centre, formally called the International Centre for Research in Agroforestry (ICRAF), is called the 'three bed system'. To construct this system you will need some wood or bamboo sticks. First, make a rectangular frame about 30cm high, 1.5m wide and 3m long. (*See figure 8*) Lay the bamboo or wooden poles on the frames to form a base leaving holes big enough for air to pass

through for ventilation but not so big that the organic matter and compost can fall through. Be careful not to use material that rots quickly or the bed will collapse. Make three of these frames side by side about 1 m apart. Pile the chopped organic waste onto two beds to a height of about 1 m, leaving the centre bed empty for now. (See figure 9A) After a week, check the temperature of the piles by sticking your hand in them. Check them again in about two weeks; they should have cooled down. With a pitchfork, mix each pile so that it becomes loose and the material at the bottom is exposed to the air. After two more weeks, remove the outside layer of material from each pile and put it on the centre bed.



(See figure 9B) Over time, remove all material from the outer layer of the piles and place it on the centre bed on top of the other material. Continue to do this until all the material has been moved from the outer beds to the center bed. (See figure 9C) Mature compost will have only about one-fifth of the volume of the original organic material from which it was made. You can now begin the process again by placing fresh organic material on the outside beds. After about four weeks, move the material from the centre pile to a storage area and leave it to mature. When it is mature, you should not be able to see any chunks of organic matter (such as bark or leaves) in the pile. To check that the compost is ready to use, wait until the compost is light brown and looks like ground coffee. Then put two handfuls of moist compost into a plastic bag and leave it in a cool, dark place for 24 hours. Open the bag. If there is no gaseous smell, the compost is ready. If there is a gaseous smell, leave the pile for a few more days and then test again. If compost is used before it is ready, it may burn the plant or it may lack the essential nutrients required by the plant for healthy growth. (WIGHTMAN, 2000)

#### THREE BED SYSTEM



Pile chopped organic waste onto two beds to a height of about 1m, leaving the centre bed empty.



After five weeks, remove outside layer of material from each pile and put on centre bed.



Over time, remove all material from outer layer of piles and place on centre bed. Continue until all the material has been moved from outer beds to centre bed.

FIGURE 9

<sup>-</sup> THE AGROFORESTRY FIELD GUIDE: A TOOL FOR COMMUNITY BASED ENVIRONMENTAL EDUCATION -

#### 1.8 How To Prepare Manure

Manure is also an important source of plant nutrients and can be added to soil to improve both texture and fertility. Types of animal manures differ in the amount of nutrients they contain. Chicken manure has a higher nitrogen, phosphorous, and potassium (NPK) content than any other domestic manure, with a 20:16:9 NPK ratio. Sheep and goat manure have a ratio of 19:7:20; cattle manure has an NPK ratio of 12:3:9; and pig manure has a ratio of 10:7:8. Prepare and test manure in the same way as you prepare and test compost (*refer to section 1.7*). Test for readiness after six to ten weeks. (ATIK)

#### 1.9 STARTING SEEDLINGS

Seedlings can be started in three ways. They can be raised in a seedbed and, when sufficiently mature, planted out in the field; they can be germinated in a seedbox, transplanted to a pot and then planted in the field; or they can be sown in a pot and then planted in the field. All three ways have advantages and disadvantages.

Bare-rooted seedlings (those from seedbeds) are easier to transport to the planting site, require less care in the nursery, and are cheaper because there is no need for pots. However, they need more space and time in the nursery and are at risk of damage and death when the roots are exposed to the air after being removed from the seedbed.

Similarly, germinating seeds in a seedbox and then pricking them out and transplanting them in a pot can often cause the roots to be damaged. The seedlings may also experience shock from being transplanted and, as a result, growth may slow down.

Finally, while plants sown in pots are heavier to transport to the planting site, and their roots require careful pruning, they are often easier to care for and will be healthier when ready for planting in the ground. It is important to select the method most suitable for the species being grown.

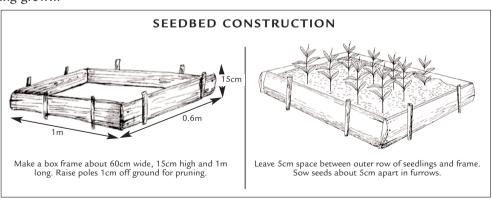


FIGURE 10

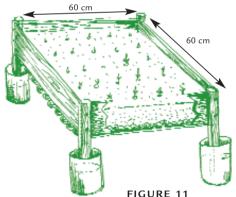
#### 1.10 Making and Using Seedbeds

To make a seedbed, collect some tree branches or bamboo poles with a combined width of about 20cm. Lay them down to make a box frame about 60cm wide, 15cm high and 1m long. (see figure 10) Raise the branches/poles 1cm off the ground so that a machete blade can be passed underneath when pruning the roots, and secure the poles with pegs. Fill the frame with good potting soil (refer to section 1.6) so that the soil reaches the top of the frame. Make furrows 10cm apart along the length of the seedbed. Leave a 5cm space between the outer row of seedlings and the frame. Sow seeds about 5cm apart from each other in the furrows. Cover the furrows with soil to a depth of no more than two-thirds the thickness of the seeds. Water the seedbed and cover with mulch. (Bunderson, 1995)

#### 1.11 Making and Using Seedboxes

Construct a seedbox with dimensions of about 60cm x 60cm and 10cm deep. Make holes in the bottom of the box and raise the box on legs to allow for drainage. To provide some stability and to prevent ants from climbing the legs and attacking the seedlings, stand the legs in cans filled with water. Cover the bottom of the box with a 3cm layer of gravel and then fill the box with a rooting medium made of equal parts of soil, sand, and compost. (See figure 11) Pour

boiling water over the filled box to sterilize it. Make furrows in the soil, place seeds in the furrows (or broadcast the seeds evenly) and cover them with a fine layer of soil. Water the box to keep the contents constantly moist. (ATIK, 1992)



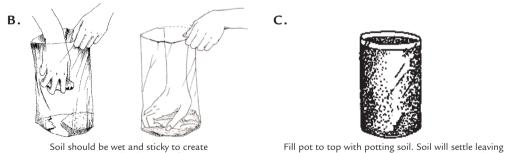
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#### 1.12 Making And/Or Using Seedling Pots

Polythene pots or folded banana leaves can be used for potting seedlings. The important thing is that the container should be sufficiently durable to last two to three months. The bottoms of the pots may be open or closed. However, open ones are preferred as they drain better and are less likely to cause root deformities. (*See figure 12A*) If you are using openended pots, wet some soil until it is sticky and push it to the bottom of the pot, filling about 2cm at the bottom. (*See figures 12B*) This will make a compact seal and prevent the soil falling through the pot. After this is done, fill the pot to the top with potting soil. (*See figure 12C*) The soil will settle, leaving about a 0.5cm gap at the top, which will retain water when the pots are watered. Insert a stick into the centre of the soil in the pot to the desired depth (two-thirds the diameter of the seed) and plant the seed in the hole. Water the pot to keep the soil moist.

# MAKING OPEN-BOTTOMED SEEDLING POTS Use Polythene pots OR folded banana leaves

Open bottomed pots are preferable to ensure good drainage. They should be durable enough to last 2-3 months.



a compact seal at bottom of pot

a gap to retain water when pots are watered.

FIGURE 12

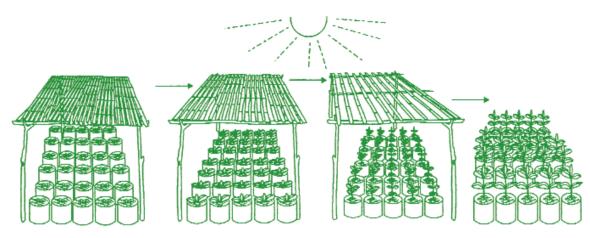


FIGURE 13

#### 1.13 SHADE

Seedlings need to be shaded from extreme heat. As the plants grow larger and become stronger, the amount of shade should be slowly reduced, so that when it is time for planting out they are 'hardened' and can survive on their own without shade. (*See figure 13*) Thatch, large leaves, rattan or bamboo mats can all be used to provide shade. The shade provided should not be so dense that no light can enter. One method for hardening plants is to expose the plants to full sunlight for one hour per day, then for two hours, then three hours and so on until the plants no longer need shade. Another method is to cut the shade in the nursery by half after three to four weeks. After another two to three weeks, remove the shade completely.

#### 1.14 PRICKING OUT AND TRANSPLANTING

If germinating seedlings in seedbeds or seedboxes and then transplanting them into pots, the seedlings should be 'pricked out' once their first two true leaves have developed. This will generally be when the seedlings are about three to five weeks old and around 3-8cm tall. The night before transplanting, water both the soil in the pots and the seedlings in the seedbeds or seedboxes. When transplanting, work in a well shaded area as direct sunlight can kill the pricked out seedlings very quickly. Make a hole in the soil in the pot deep enough for the seedling root, making sure that the hole is straight. Throw away any poor quality seedlings. Loosen the soil around the seedling and hold the leaves upward. Squeeze the leaves gently together, and pull the seedling out of the soil. (*See figure 14*) Now place the seedling in the pre-prepared hole in the pot, making sure it is straight. Water the pots immediately after transplanting and place under the constructed shade.



FIGURE 14

#### 1.15 HARDENING OFF AND PLANTING OUT

Before trees can be successfully planted in the field they should be hardened off. This means that they should gradually be given less water and less shade, so that by the time they are ready for planting they will be able to withstand the natural environment with minimal care. Once the shade has been gradually removed (*refer to figure 13*), gradually reduce watering from twice to once per day. This should be done four to six weeks before planting out. After another week, reduce watering to once every other day until the time for planting out. It is also important to increase root pruning to once a week before planting out (*refer to section 1.16*). Do not plant out any plants that look deformed or unhealthy. Throw them away.

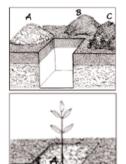


FIGURE 15

Plant out at the start of rains, and ideally on a wet day. Plant out during the early morning or evening to avoid extreme heat. Most trees are ready for planting out when the stems of the trees are equal in length to the roots, and both stems and roots are about 20cm long. (See figure 17A) Carry the potted

seedlings to the site and remove the pot by cutting off the bottom 1cm of the pot and making a slit down the side. (*See figure 17B*) For seedlings in seedbeds, remove the seedlings by cutting squares around them and carefully lifting them and the square of soil out of the bed. (*See figure 17C*) Keep the seedlings moist and wrapped in leaves or put in a basket and cover with a wet cloth to protect them from the sun. At the site, dig holes measuring 30cm deep and 30cm in diameter. (*See figure 15*) Place the subsoil (A in the figure) and the topsoil (B in the figure) in two different piles. Mix the topsoil with equal amounts of manure (C in the figure) and put the mixture back in the bottom of the hole. Place the seedling at the center of the hole, keeping the root collar level with the ground. (*See figure 17 for proper and incorrect planting methods.*) Replace the subsoil at the top of the hole and pack the soil firmly around the seedling. Water the seedling. Add mulch to prevent weeds from establishing and water evaporating. If necessary, construct a small enclosure around the tree to protect it from browsing animals. (*See figure 16*)

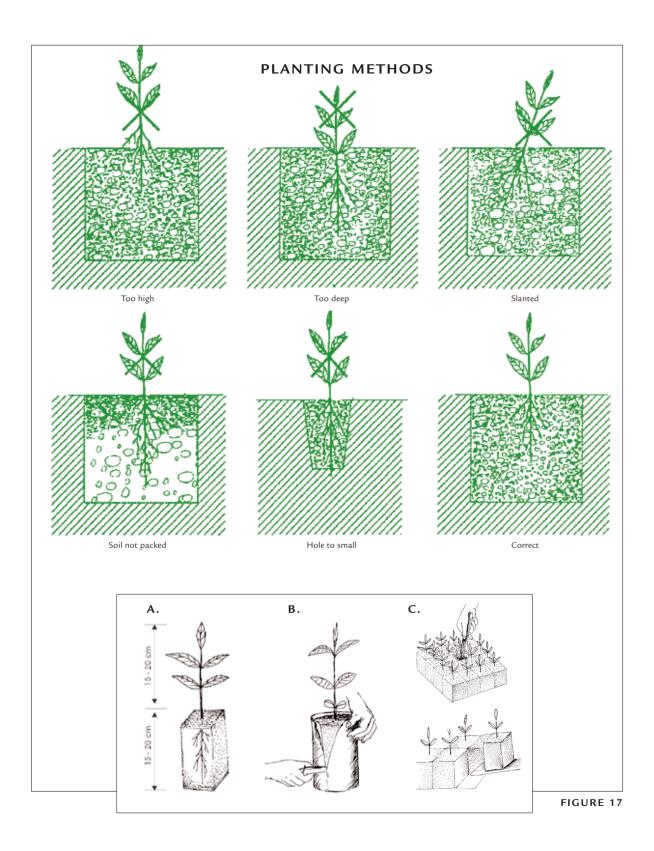
#### PROTECTIVE SEEDLING ENCLOSURES







FIGURE 16



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#### 1.16 ROOT PRUNING

Root pruning helps to produce robust root systems and to prevent roots growing into the ground in the nursery. Three methods for root pruning are discussed here. The first is root pruning in the seedbed. To prune the root in this situation, use a machete or long blade to cut vertical rows through the soil between all seedlings in the bed. After this, run the machete along the ground under the seedbed from all four sides.

For seedlings in pots, simply move the pots every once in a while. This will prohibit any root growth. (See figure 19) Prune the root every two to three weeks and three to four days before planting out.

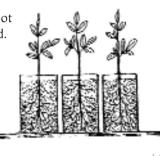


FIGURE 18

The third method of root pruning is air pruning. Only some species can be pruned in this manner so the farmer should test this with a small amount of seedlings first. Make a platform with wire mesh laid on some brick or logs. (See figure 18) Lay the seedlings on top of the mesh. As soon as the roots make contact with the air, they cease growing vertically and form fine lateral roots.



FIGURE 19

#### 1.17 SEEDLING MANAGEMENT (WATERING, WEEDING, CONTROLLING PESTS)

Water new seedlings twice a day. As climate and soil differ from place to place, seedlings raised in some areas may require more (or less) watering than seedlings raised in other places. The general rule is to give plants enough water to maintain turgidity in the leaves. If the leaves begin to wilt, they are not being watered enough. To avoid over watering, allow the soil to dry out slightly before watering again. It is best to water in the early morning or late afternoon when it is cool. Water so that the soil becomes completely wet and water begins to run out the bottom of the pot.

Weeding plants in the nursery is also important. Weeds compete for the nutrients and water that the seedlings need to thrive. Clear weeds often and discard the weeds in a compost pile.

To control pests, keep things tidy, sterilize equipment before use, and destroy diseased plants. Some natural, plant-based products can also be used to minimise insect and fungi attacks. Some common ones are suggested below.

Neem (*Azadirachta indica*) This tree can be used as a fungicide, insecticide and bactericide. Wash and remove the husks of mature seeds and allow the seeds to dry completely. Take 12 handfuls of seeds and grind into a fine powder. Mix the powder in 12 litres of water and soak overnight. Strain the liquid and apply.

**Custard apple** (*Annona Squamosa*, *A. muricata*) This fruit can be used as an insecticide. Collect two handfuls of seed and dry them. Grind the seeds into a fine powder and mix with 4 litres of water. Soak overnight. Strain the liquid and apply.

**Chilli pepper** (*Capsicum frutescens*) This can be used as an insecticide. Collect two handfuls of chilies and dry them. Grind the chilies into a fine powder and mix with 2 litres of water. Soak overnight. Strain the liquid and apply.

**Gliricidia** (*Gliricidia sepium*) Roots, seeds, and leaves can be used as an insecticide or to prevent rats from eating seedlings. Mix 300g of dry plant material with 1 litres of water and soak for 24 hours. Strain the liquid and apply.

Papaya (Carica papaya) This can be used as a fungicide. Finely chop 1kg of dry leaves and mix with 1 litres of water and soak overnight. Dilute with 4 litres of water and apply to the soil and to the bottom of leaves.

Garlic and onion (*Allium sativum*, *A. Cepa*) This mixture can also be used as an effective pesticide. Mix 500g of finely chopped material in 10 litres of water. Allow to ferment for one week. Dilute with another 10 litres of water and apply to the soil.

(WIGHTMAN, 2000)

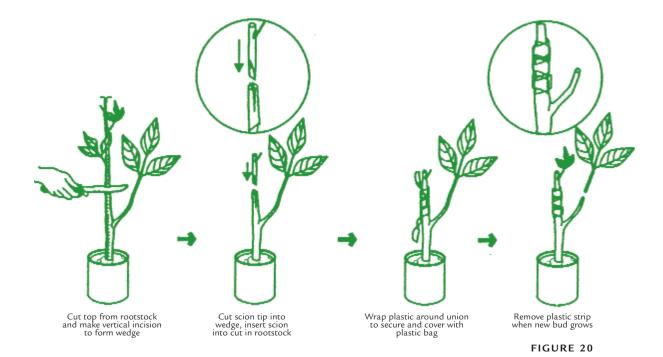
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#### 1.18 VEGETATIVE PROPAGATION TECHNIQUES

There are several different methods used for asexual or vegetative propagation of plants. Some of the most common methods are explained below. Note that here 'rootstock' refers to local trees that are used for their root system because they are adapted to the local soil, climate, and pests. These rootstock are often grafted or budded with 'scions', which are usually branches or other vegetative material taken from trees that bear improved varieties of fruits, are resistant to fruit diseases, or yield more than the rootstock variety.

#### Wedge grafting (See figure 20)

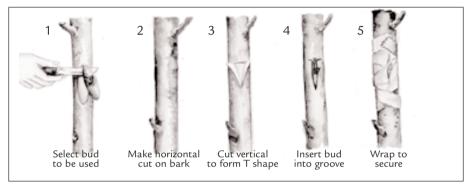
- 1. Cut the top from the rootstock leaving a flat surface.
  On this flat surface cut a vertical incision in the shape of a wedge.
- 2. Cut a scion tip in the form of a wedge so that it can fit in the cut on the rootstock
- 3. Insert the scion into the rootstock.
- 4. Wrap a plastic strip around the union to keep the two pieces secure.
- 5. Cover the scion with a plastic bag to retain moisture.
- 6. Remove the plastic bag when new buds begin to grow.
- 7. Remove the plastic strip and plant the seedling.



- SECTION ONE: THE TREE NURSERY -

#### T budding (See figure 21)

- 1. Select the bud to be used and make an upward cut starting 2cm below the bud and ending about the same length above.
- 2. Make a horizontal cut on the bark of the rootstock.
- 3. Make a 2.5cm long vertical cut up to the horizontal cut forming a T shape.
- 4. Lift the bark with the blade and insert the bud so that it fits tightly in the groove.
- 5. Cut any excess ends so that the bud fits well in the groove.
- 6. Wrap the bud with plastic strip to secure it, leaving the bud exposed.
- 7. After the bud has set (usually four to six weeks), remove the tape.



#### Chip budding (See figure 22)

FIGURE 21

- 1. Make a 5mm deep cut at a 45 degree angle into the scion about 2.5cm below the bud.
- 2. Starting about 2cm above the bud, make a downward cut to meet the first cut.
- 3. Make a similar cut on the rootstock and throw away the piece cut out.
- 4. Place the bud in the groove that was cut in the rootstock.
- 5. Tie the bud in place with plastic strip.
- 6. Remove the plastic tape after the bud has set (usually four to six weeks).

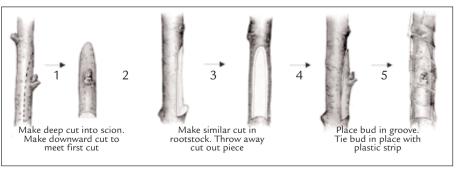


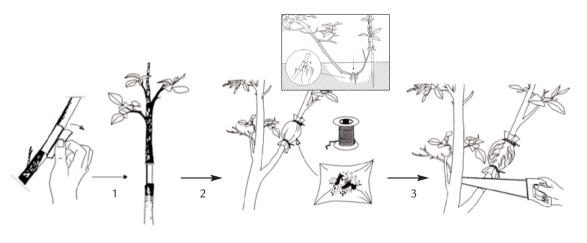
FIGURE 22

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#### Air Layering and Marcotting (See figure 23)

- 1. Cut a ring from the bark on a selected branch so that cambium is exposed.
- 2. Apply a ball of soil in a plastic sheet to the area where the bark was removed and secure tightly OR bend the branch to the ground, covering the exposed area with soil from the ground and securing it in place so that the branch remains covered with soil.
- 3. After roots have developed, cut the branch below the area that is covered with the soil and plastic.
- 4. Unwrap the branch and plant.



Cut ring from bark to expose cambium

Apply ball of soil to exposed area or bend branch to ground and cover exposed area with soil Cut branch below covered area after roots appear

FIGURE 23

#### Cuttings and Truncheons (See figure 24)

- 1. Cut one-year-old branches into cuttings (about 15-40cm long and 3-10mm diameter for cuttings and 80-120cm long and 15cm diameter for truncheons). It is best to do this when trees are resting, which is usually in dry or cool periods.
- 2. Cut a branch a few centimeters below a node at an angle. If it is available, dip the end in rooting hormone.
- 3. Remove some of the leaves and cut the remaining leaves in half so that there is less surface area for water loss.
- 4. Plant cuttings in sterilized sand immediately, and plant truncheons directly in the field after digging a suitably sized hole.
- 5. Water well to keep the soil moist until roots develop.
- 6. After the roots have grown dense enough, transfer the seedling into plastic pots or in the case of truncheons let them continue to grow where they are.

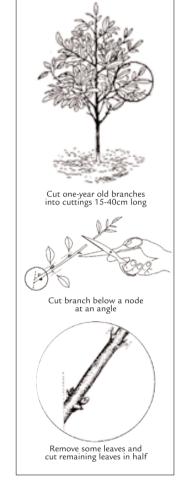


FIGURE 24



S E C T I O N T W O

## Agro-Forestry Technologies

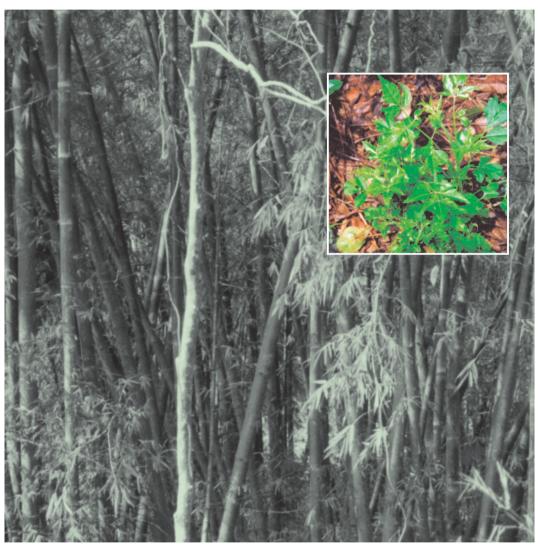


Photo above: Coppiced Melia Azedarach Inset Photo: Stand of bamboo

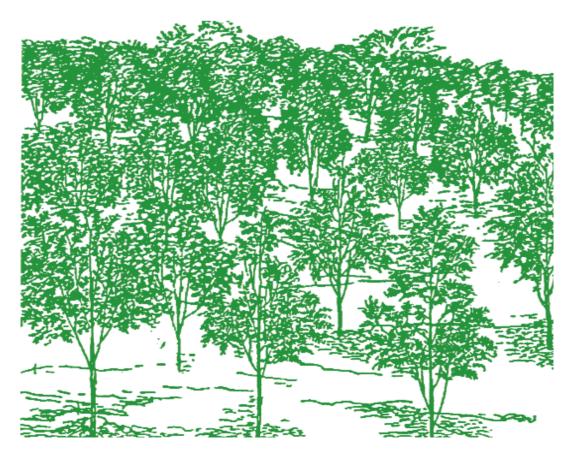
his section provides technical information on how to set up a number of agroforestry technologies that offer a variety of benefits. This section is divided into two parts based on the types of technologies described. There are technologies that offer multiple benefits for farmers including fodder, timber and fruit production and there are technologies that conserve water and soil. and improve the fertility and structure of soil. Remember that almost all technologies will have more than one benefit, and that many will have a number of benefits. Ideally, agroforestry technologies should be combined into a system using a variety of tree species, so that farmers can reap a number of benefits at the same time such as helping to restore the landscape, providing essential products, improving diet and supplementing income.

Use the description of agroforestry species provided in Section 3 and the chart in Appendix B to select tree species appropriate for your projects.

#### PART I: MULTIPLE USE TREE TECHNOLOGIES

Trees are an essential part of our lives. By planting trees in agroforestry systems, we can get the most out of trees to fulfill our needs in the form of live fences, fuel, fodder, food, medicine, green manure, and specific products such as rubber, dyes and oils.

Ideally, agroforestry systems should include a variety of tree species, so that farmers can reap a number of the benefits described above while helping to restore the landscape, and at the same time improving food security and income. This will reduce the need for harvesting from the natural forest, and for subsistence hunting.



- SECTION TWO: AGROFORESTRY TECHNOLOGIES -



#### 2.1 LIVING FENCES

Farmers can grow trees on farms in the form of 'living fences'. Many farmers build fences around their yards to demarcate their land, to keep domestic and wild animals away from their houses and crops, and to enclose domestic animals for household or commercial purposes. Fences made from sawn timber and wire have many disadvantages. Firstly, over time, the wood rots and needs to be replaced. Secondly, the materials are costly. Thirdly, natural resources need to be exploited to provide materials. Finally, the fence offers no secondary benefits to the farmer besides those of fencing. 'Living fences' (fences made from growing trees) are an excellent alternative to 'dead' fences. They require little exploitation of natural resources, are cheaper to establish and maintain, provide all the primary benefits of dead fences, and, in addition to acting as fences, provide secondary benefits, such as green manure, fodder, fruit, and fuel wood.

To establish an effective living fence that delivers the benefits of trees while acting as a fence, use species that form a dense mass and/or have thorns. Such species create a tight, impenetrable barrier to animals. Having selected your species, demarcate your fence line. Sow seeds of the desired species every 20cm. Plant seedlings every 40cm, or plant truncheons about 1m apart and 30-50cm deep until the line is complete. Some species may need to be protected from grazing animals until they are large enough to withstand such grazing. This is usually about one year.

The trees in the living fences should be trimmed to about 50-75cm high after the second or third year to promote lateral growth, and thus ensure a denser hedge. (BUNDERSON, 1995) Trim the sides of the hedges as well to minimise excessive unwieldy growth. Some of the trees in the fence may be left to grow upwards so that they yield poles and fruit.

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#### 2.2 FODDER

Trees grown on farms in agroforestry projects can also provide fodder for domestic animals such as buffalo, cows, pigs, and goats. Providing for these animals is important as they generate income, supplement the household diet with meat and dairy products, and provide a source of manure for the garden. Buffalo are also excellent draught animals that can be used to plough fields and carry heavy loads. Fodder banks are a cost effective way of feeding cattle while also providing secondary materials such as fuel wood and small poles.

Fodder trees can be planted on a plot of land set aside for their production, they can be grown on the boundary of the farm, playing a secondary role in land demarcation. Fodder can be grown in the form of grass, and trees and grass can be grown in a mixed stand. (*See figure 25*) In order to establish fodder trees on a plot of land allocated specifically for this purpose, plant trees 0.9m x 0.9m apart. If trees are interplanted with grass, plant trees 0.9m apart with alleys of 4.5m between tree rows. Plant the desired grass species with 0.9m x 0.45m spacing in the alleys (Bunderson, 1995). Start pruning the fodder trees in the second growing season when the height of the trees has reached at least 1m. The number of times per year that the trees can be pruned depends on the secondary use of the trees. If, for example, the farmer wants to grow poles from the fodder trees, they should be pruned only once per year. However, fodder can be cut from the trees daily as needed.

When deciding how many trees to grow for fodder, keep in mind that growing cattle need about 12 per cent crude protein in dry form for normal growth. Good quality grass usually contains about 8 per cent crude protein in dry form and an optimal grass/legume mixture contains about 20 per cent crude protein with high calcium content. (ATIK) Cattle usually require about 2 per cent of their body weight in dry forage or 8 per cent fresh material per day. So if a cow weighs 500kg, it should be fed about 10kg of dry fodder each day.

#### **FODDER TREES**

Fodder can be grown in the form of grass  $\underline{\mathsf{OR}}$  trees and grass can be grown in a mixed stand



Land set aside for tree and grass fodder production



Fodder trees with first harvest of grass



Cattle require 2% of their body weight in dry forage or 8% fresh material per day

FIGURE 25



#### 2.3 WOODLOTS

Wood and bamboo is an essential commodity in many households around the world and is of particular importance in rural areas. Many rural families rely on these for fuel, for building or repairing homes, for making tools, and for making furniture and various other household items. Many people harvest timber from the forest or buy it from a company that either grows trees on a plantation or harvests them from natural forest. In order to avoid destroying natural forest and to minimise the high costs of purchasing timber, farmers can plant timber trees on their land. Woodlots on farms can also provide an alternative to illegal timber extraction from the forests, which is a common way by which locals increase incomes and meet domestic demands for wood.

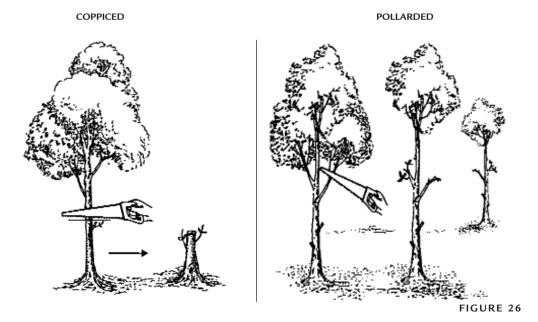
To decide what trees to plant in order to supply the household with fuel and timber products (such as buildings, tools and furniture), the farmer should first determine what the timber is needed for. He or she will then need to find out what species are suitable for this use (or combination of uses) grow easily and quickly in the region.

How the trees are planted will depend on their end use. If they are going to be used for poles, then the trees should be planted close together. In general, this promotes self-pruning and limits lateral branch growth, resulting in tall, straight poles.





With closer spacing, many more poles can be produced on the same plot of land. If trees are going to be produced for fuel, some side branching may be desirable, so trees can be spaced a bit farther apart. If trees are being grown to produce large timber for construction or furniture, larger spacing is required to allow enough room for satisfactory growth. Small diameter poles are produced with a spacing of  $1.8m \times 1.8m$ , medium-sized poles or firewood with a spacing of  $3.6m \times 1.8$ -3.6m, and large diameter timber for construction and furniture with a spacing of  $5m \times 5m$ . (See figure 27) The rows of trees should be alternate. Plant out the seedlings and manage the lot according to Section 1. Harvest the trees when they reach the desired size and replant or wait for regrowth if the trees are coppiced or pollarded (figure 26).



- SECTION TWO: AGROFORESTRY TECHNOLOGIES -

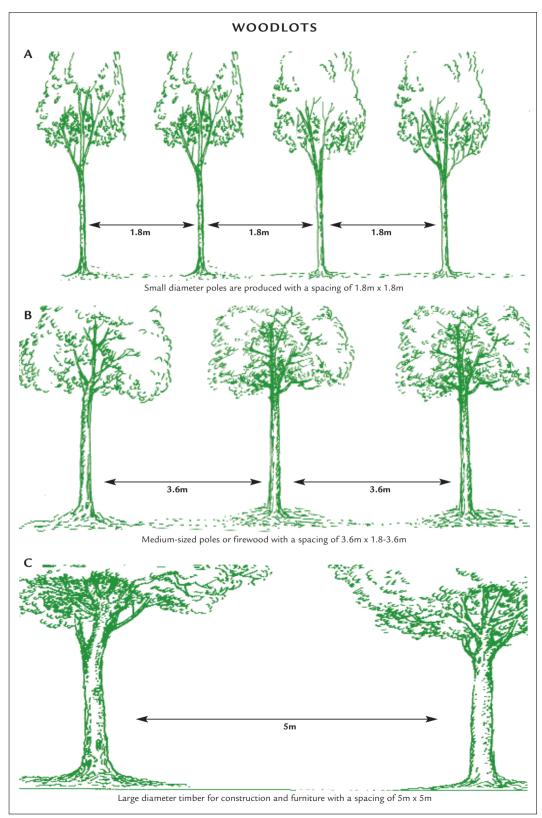


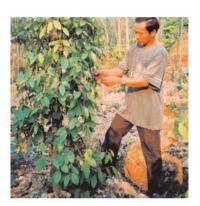
FIGURE 27

#### 2.4 Multipurpose Tree Gardens

Trees offer many benefits to human communities. They provide materials to build and make houses, fences, bridges, animal shelters, furniture, tools, artwork, paper, rope, clothing, musical instruments and so on. Trees also provide fuel, fodder, food for humans, medicine, green manure, and specific products such as rubber, dyes and oils. They offer food, shelter and homes for birds and primates, food for herbivores, hunting grounds for carnivores, and microhabitats for amphibians and reptiles. They also protect soil from erosion, and waterways from sedimentation. Trees also help to protect and improve air quality and limit the 'greenhouse effect'



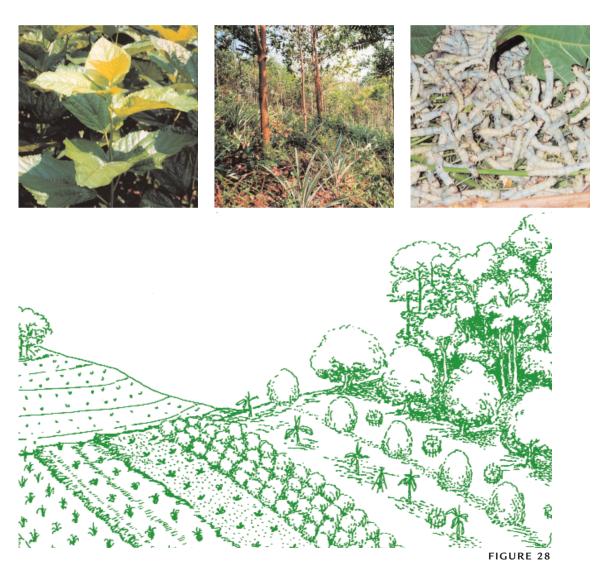




Multipurpose tree gardens can both help to restore the landscape for biodiversity and ecological service reasons and improve the household's diet and income. (*See figure 28*) Farmers can plant their farm with an integrated system of trees so that they support each other and deliver the environmental benefits found in a natural forest. An ecologically healthy farm will be more productive than one in which the natural ecological systems are degraded.

To establish a multipurpose tree garden, first make a brief survey of the local forest to get an idea of the composition of species and space between trees that exists naturally in the area, and to understand the mutual relationships between local plants and animals. (These relationships may include epiphytic plant and tree relationships, or flower and bird pollinator relationships.) Plant a mix of species in a pattern that encourages different animals and birds to frequent the garden. This promotes biodiversity by reducing fragmentation of natural forest and creating possible land bridges between forest areas. It also provides a way of supplementing the household's income and diet. Plant the trees so that they can co-exist and do not compete with each other for light, nutrients, or water – for example, not too close together.

To work out what species of trees to plant in the tree garden, write a list of what final products are desired and what species grow naturally in the forest, promote biodiversity, and provide ecosystem functions that are important to the area. From this list, select species that can grow on the land available and in different canopy levels and tolerance of shade and light. The mix may include exotic species selected for greater economic and household value, though care should be taken that these species are not likely to invade the natural forest. Some farmers may mix fruit trees with nitrogen fixing trees and trees providing medicine, ground crops and/or timber. There are many combinations to choose from. See photos for examples.



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Orchards are another agroforestry system that can offer farmers both food and an income. When planting, space seedlings according to the desired width of the tree crown for optimal fruit production. To encourage growth, place manure in the planting hole before planting, and apply fertilizer occasionally. Prune back the branches of the canopy to maintain a uniform structure that is easy to manage.

## 2.6 TAUNGYA

Taungya involves intercropping young tree seedlings that will eventually become a woodlot or orchard, with growing agricultural crops. (*See figures 29A & B*) The trees selected may also contribute to soil improvement. Intercropping can continue until competition for light makes it no longer possible. (This may mean several seasons.) After this, trees are left as pure stands, with no additional agricultural cropping until after the trees are harvested. (*See figure 29C*)

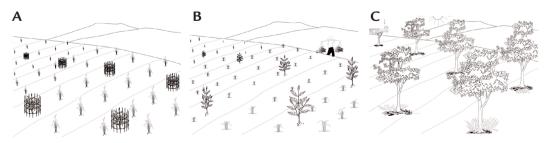


FIGURE 29



# 3.7 Systematic Tree Intercropping

Similar to taungya, intercropping of trees with crops can provide farmers with food while also providing them with various other products, such as fuel wood, poles, fruit, and fodder. The trees planted may also improve the soil. However, unlike taungya, systematic tree intercropping involves continued cropping of trees with crops. Instead of abandoning the agricultural crops once the trees compete too much for light, the trees themselves are pruned, so that the two can thrive simultaneously.

Plant trees throughout the field at a spacing of  $10m \times 10m$  and, as the trees grow larger, thin them so they are about  $20m \times 20m$  apart so that they do not compete with the crops. Prune the canopy as well to limit shade on the crops below.

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# PART II SOIL AND WATER TECHNOLOGIES

In many rural areas throughout the world, trees are cleared to make room for growing food crops. This is an important and vital practice for the survival of all humanity. However, the over harvesting of forests and the bare land left behind can create a number of problems. In addition to the loss of materials for uses such as medicine, fuel, construction, and diet, there can also be environmental problems that threaten human communities. For example, degradation of forestland on sloped areas causes irreversible damage to farms and poses a threat to human lives. When heavy rains rush over the exposed land that has no trees to cover and bind the soil, high levels of soil erosion occur. Erosion on farms leads to both a loss of nutrients in the soil (and a consequent decrease in crop yields) and sedimentation of waterways (and a consequent decrease in the abundance of aquatic life). To make up for a decrease in productivity, farmers may shorten fallow periods and clear more of the forest to provide more agricultural land. This is often the start of a vicious cycle. Increased clearing leads to increased erosion, which leads to loss of productive land and the need for more clearing. At the same time, the intense floods that follow clearing threaten many lives and homes. Furthermore, sedimentation of rivers may poison the water for humans and kill the fish and animals that depend on the rivers.

Fortunately, it does not have to be a choice between land for agriculture and land for trees. Agroforestry allows for both to exist at the same time in a way that provides benefits for humans, other living things and the environment.

Agroforestry can help to conserve soil and water, and improve the quality and nutrient content of the soil, thereby reduce the need to cut down the forest and allow for the replanting of slopes. For farmers currently using swidden agriculture, technologies such as terracing, contour hedgerows, improved fallow, and alley cropping offer increased soil fertility and

better soil and water conservation. These improvements increase crop yields and food security while decreasing the need to abandon exhausted fields and cut forests for new, more productive land.



#### 2.8 Making and Using An A-Frame

An A-frame is an essential tool in preparing the land for many of the agroforestry technologies mentioned in this manual. It enables a farmer to mark the slope, or contour of the land, so that it can be used in a way that minimises erosion.

- 1. Find three wooden poles, two that are 3m long and one that is 2m long, some string (about 5m), and a stone about the size of a fist. (See figure 30A)
- 2. Tie the two 3m poles together at the top.
- 3. Tie the 2m pole across the two longer poles about 1m from the bottom, to form an A.
- 4. Tie the string to the structure at the point where the two longer poles (legs) are fastened together, so that it hangs about 5-10cm below the horizontal pole.
- 5. Tie the other end of the string to the stone. (See figure 30B)
- 6. Calibrate the A-frame by standing it on a level surface. Mark the point where the string passes through the center of the horizontal pole. Mark the two spots made by the legs of the frame on the ground. Reverse the position of the A-frame legs. If the string now passes through the same spot on the horizontal pole, this is the midpoint. If it differs, mark the midpoint between the area the string is hanging in now and the area it hung the first time. This is now the midpoint. (*See figure 30C*)
- 7. Drive a stake into the ground at the highest corner of the field and place one of the legs of the A-frame next to it.
- 8. Hold this leg in place and move the other leg around until the string hangs over the midpoint. Drive another stake into the ground at this point.
- 9. Hold the second leg in place and pivot the first leg around until the string again hangs over the midpoint. Drive a stake into the ground at this location. Continue this process until you reach the other side of the field. You will now have a line of stakes on ground with the same contour. (See figure 30D)

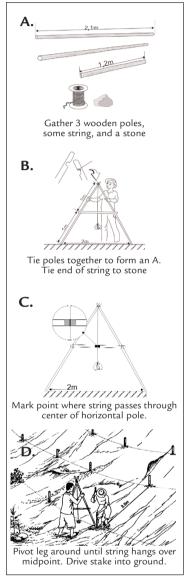


FIGURE 30

- 10. Move downhill from the first stake to the position of the next contour. This will be approximately 10-15m below the first contour but will vary according to the slope.
- 11. Repeat steps seven to ten above and work your way across the field.
- 12. Continue to mark contours across the field by repeating steps seven to ten at intervals down the slope.

#### 2.9 CONTOUR CANAL

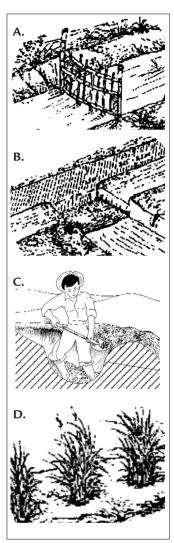


FIGURE 31

Contour canals are suitable for controlling the flow of water and minimizing erosion on deep porous soil. (*See figure 31 and 32*) (ATIK, 1992)

- 1. Make a drainage canal at the top of the farm that gradually winds down the slope at a one degree angle. This canal will cross and link with the out flow ends of the contour canals, which run across the slope. The drainage canal should empty out into a gully carrying the excess water away from the farm. The depth and width of the drainage canal may vary according to slope and average rainfall but may be about 0.5m wide.
- 2. Build check dams in the drainage system to slow down water flow by driving stakes into the ground across the width of the drainage canal. Cuttings or truncheons can be used to make a living check dam. Weave split bamboo between the stakes. Start at the top of the canal and work down. (*See figure 31A*)
- 3. Dig soil traps about 0.5m above each check dam and about 0.8m deep and 1m long. The soil should be removed from the trap periodically and placed in the field. (*See figure 31B*)
- 4. Using an A-frame, mark contour lines on the field. (refer to section 2.8)
- 5. Dig out the soil on the contour line creating contour canals about 50cm wide x 30cm deep and place the dug out soil on the top edge of the canal, creating a mound. (*See figure 31C*)
- 6. Plant grass and leguminous trees on the mound for stabilization and, when pruned, for fodder or green manure. (*See figure 31D*)

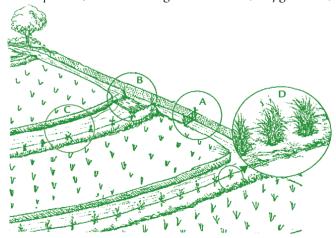
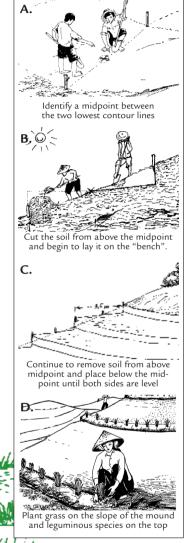


FIGURE 32

#### 2.10 BENCH TERRACING

While this technique is very time and labor intensive, it is also the most effective way to minimise erosion.

- 1. Using an A-Frame, mark contour lines on the field. (refer to section 2.8)
- 2. Starting from the bottom of the field, identify a midpoint between the two lowest contour lines. (*See figure 33A*)
- 3. Cut a level 50cm depressed "bench" along the lower contour line to place the soil from above the midpoint on.
- 4. Remove the topsoil from the area below the midpoint and set aside for later placement on the surface of the terrace.
- 5. Cut the soil from above the midpoint and begin to lay it on the "bench". (See figure 33B)
- 6. Build a mound on the bench so that its height is level with the midpoint and it slopes upwards towards the hillside.
- 7. Continue to remove the soil from above the midpoint and to place it below the midpoint until both sides are level (*See figure 33C*)
- 8. Build a contour canal below the mound at the bottom of the now level step.
- 9. Plant grass on the slope of the mound and leguminous species on the top part for fodder or green manure. (*See figure 33D*)
- 10. If the farm is in a rocky area, the mound can be made as a rock wall.







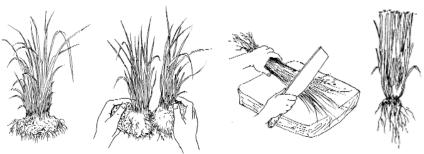
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#### 2.11 CONTOUR VEGETATION HEDGEROWS

This technology is particularly good for hard soils. (BUNDERSON, 1995)

- 1. Using an A-frame, mark contour lines in the field.
- 2. Build furrows or contour marker ridges on the contour line and align the crop ridges to the marker ridges. Align the upper half of the area between two marker ridges to the top marker ridge and the lower half of the area to the lower marker ridge.
- 3. For vetiver grass, dig out clumps of vetiver from the soil and cut the leaves so that they are about 20cm long and the roots are 10cm long. Plant 10-15cm apart. (See figure 34)
- 4. For Napier grass, dig out clumps from the soil and plant the clumps on the contour line at a 45 degree angle and at a depth of 8-10cm so two nodes are buried. Space clumps 20cm apart.
- 5. Trim the grass to a height of 40cm to encourage tillering and avoid shading. The cut grass can be used for multiple purposes such as thatching and making of brooms.
- 6. Plant leguminous trees above the furrow lines 2m apart.



Dig out clumps of vetiver grass

Cut leaves 20cm long and roots 10cm long

FIGURE 34

#### 2.12 ALLEY CROPPING

This system is used to improve the structure and nutrient content of soil and to control erosion while providing secondary products to the farmer such as fuel wood and, sometimes, fodder. Alley cropping involves growing trees that improve the fertility of the soil (such as leguminous species) with annual crops (such as rice or maize).

Directly sow leguminous species 20cm apart on the sides or top of ridges. Thin to one plant per hole so that there is one plant every 40-60cm. For larger trees, plant one

seedling every 1m). On flat land, plant the rows 5.5m

apart; on steep land about 4.5m apart. (BUNDERSON, 1995)

Prune the hedges when they reach about 1m in height, which is usually during the second growing season. Cut the branches with an upward slant to avoid fungal growth. (*See figure 35*) Prune a second time if and when the shrub begins to shade the crop and inhibit its growth. Prune a final time just after the crop is harvested. Distribute the green manure in the furrows and on the ridges of the field, and cover with soil if possible.

(See figure 36)

FIGURE 35





FIGURE 36



#### 2.13 IMPROVED FALLOW

This system is used to improve the structure and fertility of soil and to conserve water while providing secondary products such as fuel wood. Fast-growing, nitrogen-fixing trees are grown throughout a field while cultivation is abandoned. Sow seeds throughout the fallowed field at a spacing of 90cm x 45cm, or plant seedlings at a spacing of 90cm x 90cm. (*See figure 37*) (Bunderson, 1995) After two to three years, cut the trees off at ground level and incorporate the material into the soil. (*See figure 38*) Agricultural crops may be intercropped in the first year while shrubs are small.

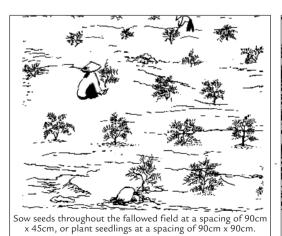




FIGURE 37 FIGURE 38

#### 2.14 Undersowing

This system is also used to improve the structure and fertility of soil while providing secondary products such as fuel wood. In this system, fast growing leguminous trees are interplanted with an agricultural crop about a week or two after the crop has been planted. (See figure 39) The tree is cut down and incorporated into the soil as green manure just before the

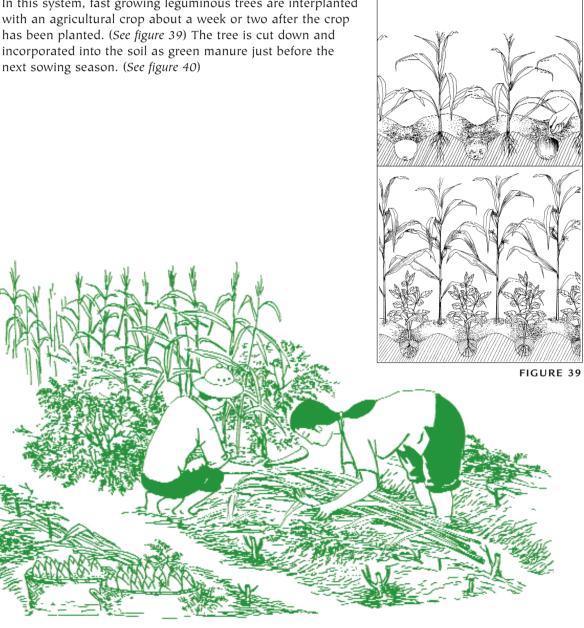


FIGURE 40

Fast growing leguminous trees are interplanted with an agricultural crop

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# S E C T I O N T H R E E

# Agroforestry Species



Photo above: Brooms made from trimmed grass from contour vegetation strips Inset Photo: Papaya he species listed in this section are suitable for agroforestry projects and offer benefits for improving both the environment and livelihoods. The list is not complete and farmers may know of other species suitable for their location and needs. Appendices B and C provide more information on plant spacing, how to estimate the number of seeds in a kilogram of a species, how to select the most suitable propagation method, and how to identify which species are suitable for which technologies.

# Common name: Apricot (Mo), Peach (Dao)



Botanical names: **Prunus mume**, **Prunus persica** Family: **Rosaceae** 

# Description

- Medium-sized, woody, deciduous trees of about 3-8m high. Many dense small branches.
- Leaves small and shiny.
- Flowers usually in clusters of threes. Peaches have pink flowers and apricots have creamy white to yellow flowers.
- ▶ Fruits small and globular. Usually enclosing a single, hard, pitted seed. Apricots are small, furry, and relatively round and become green-yellow, fragrant and fleshy when ripe. Peaches become yellow to red when ripe and their flesh is greenish-white, yellow or red.

#### **Preferred conditions**

- Light: Sun
- ▶ Altitude: 800m to 2,100m
- Rainfall: Annual rainfall of about 1,000-1,200
- Temperature: 18-24°C in summer (not exceeding 35°C). Cold (8°C), dry period needed to break bud dormancy and during flower growth. Frost sensitive
- Soil: Can grow on many soil types, such as hilly soil, plains soils, and alluvial soil along rivers and streams. Most suitable are deep soils at high elevations, with quick drainage.

- Fruit
- Medicine
- Ornamental
- Apiculture

# Common name: Avocado (Bo)



Botanical name: Persea ameriacana

Family: Lauraceae

# Description

- Dome-shaped, evergreen tree up to 20m tall.
- Leaves variable in shape and size, reddish when young, turning dark green, waxy above.
- Inflorescence fragrant and greenish.
- ▶ Fruit is large, fleshy and single-seeded, globular in shape, 7-20cm long, yellow-green to maroon and purple skin. Flesh yellow-green and of butter-like consistency. Seeds large, and globular.
- ▶ Yield depends on variety.

#### **Preferred conditions**

- Light: Sun
- ▶ Altitude: 800-1,600m
- ▶ Rainfall: Annual rainfall of 300-2,500mm and high humidity. Sensitive to waterlogging.
- Temperature: 25-33°C. Tree and fruit sensitive to wind damage.
- Soil: Very adaptable to many types of soil but requires good drainage.

- Fruit extremely nutritious
- Oil (used by the cosmetic industry in soaps and skin moisturizer products)
- Medicine

Common name: Bamboo (Luong, Met)



Botanical name: **Dendrocalamus membranaceus** Family: **Graminae** 

# Description

- 20-25m tall tree with light green, shiny and white, powdered trunk when one to two years old; trunk dark green when three to four years and becoming gray green. Trunk hollow. Branches develop from nodes.
- Leaves long, oblong and sharp tipped, dark green above, light green underneath.
- ▶ Flowers grow in clusters.

#### Preferred conditions

Light: Full sunAltitude: N/A

Rainfall: Annual rainfall of 1,600-1,800mm and

humidity over 80%

Temperature: 23-25°C

Soil: High fertile humus

Growth: Fast-growing.

#### Uses

- Construction
- Furniture
- Food (shoots)

## **Preferred conditions**

- 1. Cuttings with root hormone and technology
- Cut branches of 10-14 month old bamboo, over 1cm in diameter, dip the end of the branch and the node into root hormone to promote growth. Within 20-23 days cuttings start rooting and can be transferred to nursery
- 2. Seedbed production without root hormone
- Cuttings can be rooted in a seedbed or in plastic pots in 60 days.
- Put cuttings in the seedbed at an angle of 60 degrees in every 20cm along the furrows of the seedbed.

- SECTION THREE: AGROFORESTRY SPECIES -

#### Common name: Banana (Chuoi)



Botanical name: *Musa sinensis*Family: Musaceae

## Uses

- Fruit
- Fodder (stem)
- Weaving and dyes (stem)
- ▶ Polish and packaging (leaves)
- Medicine (young, unfolded leaves used to treat chest pains and as a cool dressing for inflamed or blistered skin; sap used to treat gonorrhea, dysentery, diarrhea and hair loss)

#### Description

- A tree-like, perennial herb about 2-9m tall.
- Shoot (false stem) is cylindrical and formed by overlapping leaf-sheaths that are tightly rolled around each other to form a rigid bundle 20-50cm in diameter.
- New leaves originate from the bottom and are tightly rolled when they emerge. The emerging leaf unfolds as a large oblong blade.
- The flower is a compound inflorescence with many groups enclosed by a reddish bract.
- ▶ Fruit is curved, green, yellow or reddish and found in clusters. Each cluster of fruits is called a 'hand' and a banana bunch includes many hands, each of which weighs about 10-20kg. The flesh is creamy and soft with many small black seeds but appears seedless.
- ▶ Yield varies with variety.

#### **Preferred conditions**

- Light: Grows best in full sunlight but excessive exposure causes sunburn.
- Altitude: Up to 1,600m
- Rainfall: Annual rainfall of about 2,000 mm
- Temperature: Around 27°C, with range of 15 to 38°C. Sensitive to strong winds.
- Soil: Deep alluvial soil, and volcanic soil rich in nutrients (especially nitrogen and potassium). Can grow in poor, light soil.

#### **Propagation**

Dud cutting: Small trees will emerge from the base and the bulb should be dug from the soil when the mother tree has already produced fruit. This small tree can be grown directly. Cut the mother tree to force other small trees to grow.

#### Common name: Black attle (Keo la tram, Keo bong vang)



Botanical name: *Acacia auriculiformis*Family: **Mimosaceae** 

# Description

- ▶ 15-30m tall, trunk diameter of 40-50cm.
- Roots have nitrogen-fixing nodules.
- Leaves are lance-shaped, 10-16cm long, thick and dark green.
- Flowers are yellow and found in clusters.
- Fruits are constricted pods containing three to six seeds.
- Seeds germinate within 6-15 days of sowing.
- Can produce from 15-20m³/ha of wood after five years of growth.

#### Preferred conditions

- Light: 30% shade
- ▶ Altitude: Up to 600m
- Rainfall: Annual rainfall of 650-2,000mm
- ▶ Temperature: 24-38°C
- ▶ Soil: Tolerant to a range of soil types, including poor soil, alluvial soil, and coastal sandy soil.

- **Timber**
- ▶ Pulp/fibre production
- Fuel
- Shade
- ▶ Erosion control
- Soil improvement
- Apiculture
- Ornamental

# Common name: Benzoin (Bo de, Canh kien trang)



Botanical name: *Styrax tonkinensis*Family: *Styracaceae* 

# Description

- A medium-sized tree, 18-20m tall, with a diameter of 20-25cm. Relatively round and straight trunk with thin, white-gray bark. Contains a white or dark yellowish resin.
- Leaves ovate, 4-9cm long, 3-6cm wide with pointy tip, green above and silver pubescent beneath.
- Flower white and fragrant.
- Fruit ovoid, with a slightly pointy tip, around 1cm in diameter. Ripe fruits are green and turn to yellow.
- Fast-growing.

## **Preferred conditions**

- Light: Full sun (deciduous November-January)
- Altitude: Up to 500m
- ▶ Rainfall: Annual rainfall of 1,500-2,000mm.
- ▶ Temperature: 19-23°C. Tolerant of cold. Exposure to high temperature and drought can kill young seedlings.
- Soil: All soils except limestone, sandy and laterite soil.

- Pulp production
- Matches and wooden shoes
- ▶ Medicine (resin)
- Perfume and varnish (resin)

# Common name: Brown salwood (Keo tai tuong)



Botanical name: Acacia mangium Family: Mimosaceae

# Description

- 25-35m tall. Dense, branched canopy. Fissured greybrown to dark brown bark when mature.
- Leaves 25cm long and 10cm wide, thick and dark green.
- Deep rooted with nitrogen-fixing nodules.
- Flowers white to yellowish.
- Fruit green, turning light brown when mature.
- Seeds germinate within six to ten days of sowing.
- Vields up to 30m3/ha/yr of timber.

# Preferred condition

- Light: Full sun
- Altitude: Up to 800m
- Rainfall: Annual rainfall of 1,500-3,000mm. Intolerant of prolonged dry conditions.
- ▶ Temperature: 18°C to 28°C. Cannot withstand heavy frost.
- **▶** Soil: Deeply weathered alluvial soils.

- ▶ Pulp/fibre production
- ▶ Timber for furniture and construction
- Firewood and coal
- ▶ Soil improvement
- Erosion control
- Food
- Shade

#### Common name: Calliandra (Muong hoa phao)



Botanical name: *Calliandra calothyrsus*Family: *Mimoisoideae* 

# Description

- A small, woody tree or big shrub, 4-6m tall, 10-20cm in diameter. Short, twisted, branched, and easily broken stem. Bark black-brown. Canopy thick.
- Roots deep and extensive with nitrogen-fixing nodules.
- Leaves dark green and close at night.
- ▶ Flowers red and found in clustered balls, blossoming in the dry season.
- Fruit a brown pod about 8-11cm long, about 1cm wide, and containing 3-15 seeds.
- ▶ Seeds germinate within 10-25 days of sowing.
- Can produce 15-40t/ha of fuelwood after one year and 7-10t of dry leaves/ha/year for fodder.

#### **Preferred conditions**

Light: Sun

▶ Altitude: 250-800m

- Rainfall: Annual rainfall of 2,000-4,000mm, but can tolerate as little as 1,000 mm. Can withstand drought for a period of three to six months.
- ▶ Temperature: 22-28°C
- Soil: Lightly acidic and soft soil, especially clays developed from lava. Unsuited to drought-prone, alkaline or flooded soil.

- Firewood
  - ▶ Pulp/fibre production
  - Soil improvement
  - Shade
  - ▶ Erosion control
  - Fire barrier
  - Fodder (22% protein, 30-70% fibre and 2-3% fat)
  - Apiculture
  - Ornamental

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# Common name: Cashew (Dieu)



Botanical name: **Anacardium occidantale**Family: **Anacardiaceae** 

# Description

- Small or medium-sized tree about 6 to 15m tall and 30-45cm in diameter. Bark greyish-brown and rough with many bumps.
- Leaves 9-15cm long and 6-8cm wide. Lamina stiff and brittle, tip rounded.
- ▶ Flowers numerous and growing in a terminal inflorescence.
- Seeds develop from a swollen and juicy receptacle, called a cashew apple. Seeds are white and contain oil and starch.
- Can produce up to 48kg fruit/tree/year

#### **Preferred conditions**

Light: Sun

Altitude: Up to 1,200m

Rainfall: Annual rainfall of 1,200-2,200mm and a six month dry season.

▶ Temperature: 21-28°C

Soil: Can grow in a wide variety of poor soil such as heavy ferralitic, lateritic and coastal sandy soils.

- ▶ Timber for construction
- ▶ Charcoal production
- ▶ Food (fruit, seeds)
- Oil (used in waterproofing over paint)
- Medicine

#### Common name: Chickrassy (Lat hoa)



Botanical name: *Chukrasia tabularis*Family: *Meliaceae* 

# Description

- ▶ A big timber tree, 25-30m tall, straight trunk with large buttresses. Blackish bark.
- Leaflets 10-12cm long, 5-6cm wide.
- ▶ Flowers found in clusters and yellowish with soft hairs.
- Fruits slightly pointed at the tip, 4-5cm long, 2-3cm wide. Fruit turn dark brown when mature and contain many seeds.
- Seeds germinate within 15 days of sowing. Seedlings reach 70-90cm within seven to eight months, and 2.8-3.4m after three years.

# **Preferred conditions**

- Light: Full sun when mature, full shade when young
- Altitude: Up to 800m
- Rainfall: Annual rainfall of 1,800-3,800mm
- ▶ Temperature: 2-43°C
- Soil: Well-drained soils.

- ▶ Timber for furniture and construction
- Gum or resin
- Dyes

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#### Common name: Chinese olive (Tram trang)



Botanical name: *Canarium album*Family: *Burseraceae* 

# Description

- A big tree, 20-25m tall, with a round, straight trunk. Smooth, white bark that becomes fissured when old. Contains a white resin.
- Leaves oblong-ovate, 6-15cm long, 2.5-6cm wide.
- ▶ Flowers yellowish and white, and found in short bunches.
- Fruits are oblong to ovoid, 3-4cm long, yellow-green when mature.
- Fast growing.
- Start harvesting fruits when trees are about 10-12 years old.

#### **Preferred conditions**

Light: Full sun

Altitude: Up to 500m

Rainfall: Annual rainfall of 1,500-2,500mm

Temperature: N/ASoil: Deep humid soil.

- ▶ Furniture, construction
- Resin used for the paint industry, incense and perfume production
- **▶** Fruit

Common name: Cinnamon (Que)



Botanical name: Cinnamomum cassia

Family: Lauraceae

# Description

- ▶ A perennial, medium-sized timber tree, 18-20m tall, diameter usually more than 40cm. Straight trunk. Bark grayish-brown. Bark and leaves pungently perfumed.
- Leaves oblong, up to 20cm long and 4-6cm wide. Thick, shiny, green leaf blade.
- Flowers white, appearing in clusters.
- Fruit cylindrical, pink-violet and 12-15cm long.
- Seeds germinate within 15-45 days of sowing. Seedlings grow to about 50-70cm in 1-1.5 years.

#### **Preferred conditions**

- Light: Full sun when mature, but slightly shade-tolerant when young
- **Altitude:** 1,350-1,800m
- ▶ Rainfall: Annual rainfall of over 1,500mm
- ▶ Temperature: Up to 27°C
- Soil: Humid, deep and well drained sandy loam.

- Medicine (bark and fruit)
- Dil and spice (dried leaves and bark)
- ▶ Timber used in furniture and construction
- Firewood

# Common name: Coconut (Dua)



Botanical name: *Cocos nucifera* Family: **Palmae**, **Arecaceae** 

#### Description

- A woody tree about 20-25m tall and 30-45cm in diameter, no branches and a swollen base.
- Leaves are concentrated at the treetop, have profound lobes, and are green and glossy above, and light green beneath.
- ▶ Flower is straw- or orange-coloured.
- Fruit about 30cm x 20cm and 7kg in weight, with a hard shell, an edible white thick pulp, and oily or milky liquid.
- Produces 60-100 nuts/tree

#### Preferred conditions

Light: Sun

Altitude: Around 700m

- Rainfall: Annual rainfall of about 1,500mm
- ▶ Temperature: 21-30°C. Trees favour hot, humid conditions but cannot tolerate extremes of humidity.
- **Soil:** Soft (eg. sandy) soil with good drainage.

#### Uses

Fruit
Green manure (fruit skin).
Furniture
Ornamental
Shade
Coconut milk

House roofing (leaves)FirewoodFibre

#### Propagation

Put the fruit in sand or soft wet soil until a shoot appears. Use this shoot as a seedling and plant directly. In areas that are far from the sea, add 1 kg of salt to the soil of each tree a little distance from the tree base.

#### Common name: Coffee (Ca Phe)



Botanical name: Coffea arabica; Coffea canephora robusta Family: Rubiaceae

#### Description

#### Coffea arabica:

- Woody tree about 4-10m tall. Strong branch ramification.
- Leaves small, hard, dark green, about 15cm long and 4-5cm wide.
- Flowers on a small stem of about eight to ten flowers.
- Fruits oval and about 17-18mm long and 10mm wide, pink-red when ripe.
- Seeds green, about 5-10cm long and 4-7cm wide.

#### Coffea canephora robusta:

- Medium, woody tree about 3-8m tall with several branches.
- Leaves large, point downward and about 10-40cm long and 8-10cm wide.
- Flowers grow on stems with 30-100 flowers on each.
- Fruits are oval, light red or pink when ripe.
- ▶ Both Coffea arabica and Coffea canephora robusta begin to yield fruit at three to five years. World average is 520kg/ha.

#### Preferred conditions

- Light: Dappled sun. Coffee can be interplanted with rubber, cacao, and other trees, to help shade coffee.
- ▶ Altitude: Altitude varies with proximity to the equator. Coffea arabica generally grows at 600-2000m, while Coffea robusta can grow up to 600m.
- ▶ Rainfall: Annual rainfall for Coffea arabica 1,300-1,900 mm, for Coffea robusta about 1,300-2,500mm. Trees need relative humidity of more than 70%.
- ▶ Temperature: Both arabica and robusta are sensitive to extreme sudden changes in temperature and to frost, and prefer mild temperatures. For Coffea arabica appropriate temperature for growth ranges from 15-24°C, while Coffea robusta generally grows well in temperatures ranging from 24-30°C. Cold, hot or dry winds are not good for either species.
- Soil: Basalt soil or soil with a top layer of more than 70cm and good drainage. Can grow on many soil types.

- Drink (made from seeds)
- Medicine (used to treat intestinal diseases, and to help digestion and blood circulation)
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#### Common name: Congo pea (Dau thieu, Dau thieu ando)



Botanical name: Cajanus indicus, Cajanus cajan Family: Papilionoideae

# Description

- A woody shrub, 3-6m tall. Stem rounded, covered with white hairs. Bark dark green.
- Roots have nitrogen-fixing nodules.
- Leaves green and covered with white hairs.
- Flowers yellow and found in clusters.
- Fruit an oblong pod, 5cm long, 1-2cm wide with yellow hairs. Pods contain three to five yellowish or brown seeds.
- Can produce 8-10t/ha/yr of firewood and 5t/ha/yr of fruit

#### Preferred conditions

- Light: Sun
- Altitude: 500-600m, but can grow up to 3,000m
- ▶ Rainfall: 600-1,200mm, but can tolerate extremes of 400-2,500 mm, and is drought resistant.
- ▶ Temperature: 18-20°C, but can tolerate a wide range of temperatures, although sensitive to frost.
- Soil: Less acidic humus and well-drained soil. Sensitive to salinity and waterlogging.

- Fodder
- Resin
- ▶ Erosion control
- Soil improvement (when used as green manure)
- Shade (for example, for tea, coffee, cashew, and fruit trees)
- Firewood (stems and branches)
- Food (seeds)
- ▶ Medicine (leaves, seeds and roots)
- Apiculture

# Common name: Custard apple (Na)



Botanical name: *Annona squamosa* Family: **Annonaceae** 

# Description

- A woody shrub about 3-6m tall.
- Leaves slightly hairy beneath.
- Flowers usually in clusters of two to four, sometime solitary.
- Fruit conical, 5-10cm in diameter, the surface greenish-yellow with powdery bloom; pulp white and tinged with yellow. Seeds black or dark brown.
- Can produce 35-45kg/tree/yr.

#### **Preferred conditions**

- Light: Sun
- Altitude: Up to 1,000m
- Rainfall: Annual rainfall of 500-800mm. Resistant to drought. Deciduous during the dry season.
- ▶ Temperature: Grows in a wide range of temperatures. Humidity higher than 70% and high temperature during bud development and blossom. Sensitive to wind and mist.
- Soil: Well-drained sandy loams, but can grow on a wide range of soil types.

- Fruit
- Vermicide and insecticide (green fruit and seeds)
- Medicine (leaves, green fruits and seeds)

# Common name: Durian (Sau rieng)



Botanical name: *Durio zibethium* Family: **Bombacaceae** 

#### Description

- Large, woody tree up to 40m tall, with dark red heartwood. Bark dark red-brown, peels off irregularly.
- Leaves lance-shaped with slender and pointy tip; the upper surface densely covered with silvery or golden coloured scales, with a layer of hair beneath.
- ▶ Inflorescences of 3-30 flowers. Flowers 5-6cm long, whitish or greenish-white.
- ▶ Fruits globular up to 25cm long and 20cm in diameter, green to brownish, covered with numerous broadly pyramidal, sharp spines. Seeds up to 4cm long, completely covered by a white or yellowish, soft, very sweet aril.
- Can produce 40-50 fruits/tree/year.

#### Preferred conditions

- Light: Dappled sun when young (one to two years old), increased sun when mature.
- Altitude: Up to 800m in tropical areas.
- Rainfall: Annual rainfall of 1,500+mm distributed evenly throughout the year.
- Temperature: Over 22°C. Prefers tropical areas without seasonal climate change.
- ▶ Soil: Light, deep, well-drained soil.

- **Fruit**
- ▶ Seeds (eaten after boiling)
- Vegetable (young shoots and unripe fruits)
- Medicine
- Door construction and cheaper types of furniture.

# Common name: Elephant grass, Napier grass (Co voi)



Botanical name: **Pennisetum purpureum**Family: **Graminae** 

## Description

- A perennial grass 4-6m tall, with many internodes.
- Deep-rooted.
- Leaves smooth, soft, sword-shaped, 30cm long and 2cm wide.
- ▶ Flowers yellowish and dog tail-shaped found in clusters.
- Can yield up to 350t/ha/year and can be cut every 90 days under natural rainfall conditions.

#### **Preferred conditions**

- Light: Full sun
- Altitude: Up to 2,000m
- Rainfall: Annual rainfall around 1,500mm. Drought tolerant.
- **Temperature:** 25-40°C. Stops growing if temperature is lower than 15°C or higher than 45°C.
- Soil: Grows well on a thick layer of nutritious soil. Intolerant of flooding.

- ▶ Fodder (raw protein 7-9%, raw fibre 25-28% and dry starch 20-25%) for milk-cows, cows, buffaloes, goats, pigs and fish
- ▶ Erosion control

# Common name: Flemingia (Dau ma, Dau cong)



Botanical name: Flemingia macrophylla Family: Papilionoideae

#### Description

- A woody, branched shrub, 1-4m tall.
- Leaves light green, 10-14cm long with soft hairs.
- Roots have nitrogen-fixing nodules.
- Flowers usually violet or red, found in clustered stems, with yellowish hairs on the stem.
- Pods found in clusters, 10-15mm long, covered with fine hairs. Pods turn yellow to brown at maturity. Each fruit contains one or two small, black-brown seeds.
- ▶ Seeds germinate within 10-20 days of sowing.
- Can produce up to 30-50t/ha/year of fresh biomass, up to 8- 12t/ha/year of dry matter, and around 7t/ha of fuel wood.

## **Preferred conditions**

- Light: Slight shade
- Altitude: Up to 2,000m
- ▶ Rainfall: Annual rainfall of 1,100-2,850mm
- ▶ Temperature: 25-30°C
- Soil: Naturally found on clay and lateritic soils.
  Tolerant of acidic, drought-prone, and rocky soil.
  Cannot tolerate flooded land.

- ▶ Fodder (protein 17%) for cattle, rabbits, goats
- ▶ Soil improvement (when used as green manure)
- Erosion control
- Fuel
- Dye
- Medicine (used to treat sores and swellings)
- Shade

# Common name: Guava (Oi voi)



Botanical name: *Psidium guajava*Family: Myrtaceae

# Description

- A small, woody tree up to 10m tall. Branching from the base. Bark smooth, green to red brown, peeling off in thin flakes.
- Leaves elliptical to oblong, shiny above, fine hairs beneath.
- Flowers are solitary or in bunches of two to three.
- Fruit is globular, 4-12cm long; skin green to yellow; flesh white, yellow, pink or red. Seeds are usually numerous, and embedded in a yellowish pulp.
- Two to four year old trees will begin to produce 100-400 fruits/tree.

#### **Preferred conditions**

- Light: Sun
- Altitude: Up to1,500m
- ▶ Rainfall: Annual rainfall of 1,000-2,000mm. Fruit may split and lose flavour if ripening during a very wet period
- Temperature: 23-28°C. Can withstand range of 15-45°C.
- Soil: Suited to many soil types, including poor soil. Tolerates waterlogging, drought, and pests.

- Fruit
- Guava powder a good source of vitamin C and pectin
- Leaves used in cooking
- Dyeing and tanning
- ▶ Timber for construction
- Medicine (used to treat diarrhea)

# Common name: Guinea grass (Co ghine)



Botanical name: *Pannicum maximum* 

Family: Graminae

# Description

- A perennial grass, 2-3m tall.
- Deep rooted.
- Leaves violet and covered by white hairs.
- ▶ Flowers bell-shaped in cluster and covered by soft hairs.
- Can produce 50-100t/ha
- Can be invasive

#### **Prefered conditions**

- Light: Tolerant of shade.
- ▶ Altitude: Up to 2,000m
- ▶ Rainfall: Annual rainfall of 650-1,800mm. Tolerant of dry weather.
- ▶ Temperature: 12-31°C
- Soil: Alluvial or soil rich in calcium or iron and well-drained. Deep sands and wet soil are unsuitable.

- Fodder (raw protein 8-10%, raw fibre 29-32%, dry starch 25-28%, and minerals 11-12%)
- Erosion control

#### Common name: Ironwood (Muong den)

#### Description

- A medium tree, up to 15m tall and up to 30cm diameter. Branched.
- Leaves compound.
- Flowers clustered on stems.
- Fruit have flat hard seeds.
- ▶ Seeds germinate within four to nine days.
- Regenerates vigorously after coppicing.
- Can produce 500kg/yr of fresh green manure.

#### Preferred conditions

Light: Full sun

Altitude: Up to1,200m

- ▶ Rainfall: Annual rainfall of 400-2,800mm, but dry period should not exceed four to eight months.
- ▶ Temperature: 20-31°C
- Soil: Deep, well-drained fertile soil, but can tolerate dry and poor soil. Intolerant of salinity.

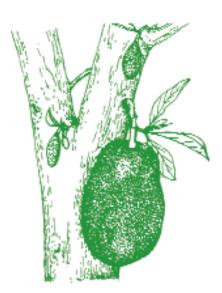
#### Uses

- ▶ Timber for furniture, artwork
- Shade
- ▶ Soil improvement
- Fuel
- Food
- ▶ Fodder, but toxic to non-ruminants such as pigs and poultry
- Erosion control (hedgerow)
- Ornamental



Botanical name: Cassia siamea Family: Ceasalpiniaceae

#### Common name: Jackfruit (Mit)



Botanical name:

Artocarpus heterophyllus

Family: Moraceae

#### Description

- Medium-sized, evergreen, woody tree up to 30m tall and 80cm in diameter with white latex in all parts. Bark rough to somewhat scaly, dark grey to greyish-brown.
- Leaves dark green and shiny above, dull pale green underneath.
- ▶ Flowers growing from older branches and main trunks. Female and male flowers develop at the same position.
- ▶ Fruit large and barrel- or pear-shaped, 30-100 x 25-50cm, with short pyramidal protuberances. When the fruit is ripe a soft, golden yellow, fleshy fragrant pulp surrounds the numerous seeds.
- Can produce 150 fruits/tree/year.

#### Preferred conditions

Light: Sun

▶ Altitude: 400-1,200m

- Rainfall: Annual rainfall 1,500+mm and a short dry season. Tolerates drought and flood.
- ▶ Temperature: 28°C, but tolerates cold.
- Soil: Well-drained and slightly acidic soils. Can grow on many soil types but prefers deep, well-drained, alluvial, sandy or clay loam soils

- Vegetable (pickled young fruit)
- Fruit
- Seeds eaten after boiling or roasting, or dried and salted as table nuts
- ▶ Fodder (young leaves)
- Timber for carving, and furniture. (The medium hardwood is resistant to termite attack, fungal and bacterial decay.)
- Medicine (pulp and seeds used as a cooling and nutritious tonic and to overcome the affects of alcohol; latex mixed with vinegar used to treat wounds caused by snakes or glandular swellings; bark used as a poultice; root used to treat skin diseases and asthma)

#### Common name: Japanese pagoda tree (Cay hoe)



Botanical name: *Sophora japonica*Family: **Papilionoideae** 

#### Description

- A perennial, medium-sized, woody tree, up to 8-10m tall. Rough bark is green with many white spots when young and turns gray when mature.
- ▶ Roots have nitrogen-fixing nodules.
- Leaves dark green.
- Flowers grow on a stem and are yellowish.
- Fruit a woody, curved pod, 2.5-5cm long, 2-3cm wide and 0.5-1cm thick. Each fruit has one to six seeds.
- Fast growing.

#### Preferred conditions

- Light: Full sun
- Altitude: Up to 300m, but can grow at up to 700m.
- Rainfall: Drought-tolerant
- **▶** Temperature: Tolerant of cold weather
- Soil: Slightly acidic, well-drained alluvial soil and sandy soil found adjacent to rivers, streams and coastal areas. Intolerant of flooded soil.

- Ornamental
- Medicine (flowers used to treat blood-related illnesses and to cool the body)
- ▶ Food dyes (flowers)
- Soil improvement (when used as green manure)
- Fodder
- ▶ Erosion control

#### Common name: Java almond (Tram den)

#### Description

- 20-25m tall and 50-60cm in diameter. Round, straight trunk. Brownish bark with black sap and aromatic scent. Thick canopy.
- Leaves with oblong leaflets 10-20cm long, 4-7cm wide, shiny above, dark coloured beneath.
- Flowers white or yellowish and found on stalks 2-3cm long.
- Fruits long and ovoid, 3-4cm long, 2-2.5cm wide, dark violet when ripe.
- Fast growing. Strong natural regeneration in open area.



Light: Full sun

Altitude: Up to 600mTemperature: N/A

▶ Rainfall: Annual rainfall of 1,500-2,500mm

Soil: Deep, well-drained, humid soil

- Construction, furniture
- Food (seed)
- ▶ Edible oil from the seed
- ▶ Sap used for fuel and to make dyes



Botanical Name: **Canarium nigrum**Family: **Burseraceae** 

#### Common name: Leucaena (Keo dau)



Botanical Name: **Leucaena leucocephala** Family: **Mimosoideae** 

#### Description

- A medium, evergreen woody tree 5-8m tall. Rounded, branched stem. Smooth, gray or brown bark.
- Roots have many nodules for nitrogen fixation.
- Leaves dark green.
- Flowers creamy-white in clustered balls.
- Fruit a narrow, long, flat pod growing in clusters. Pods green when young and turn brown/yellow when mature. Each fruit contains 15-20 black-yellow flat seeds.
- Seeds germinate within seven to eight days of sowing.
- After two years of growth, trees can produce 10-60m3/ha/yr of wood and 40-80t/ha/yr of fodder.

#### Preferred conditions

- Light: Full sun
- Altitude: Up to 1,500m
- Rainfall: Annual rainfall of 650-3,000mm. Drought tolerant and can tolerate a dry season of four to eight months.
- **■** Temperature: 25-30°C
- Soil: Wet, spongy, well-drained soil. Does not tolerate flooded, low calcium content, low pH or acidic soil.

- Firewood
- Pulp and fibre production
- Timber
- Fodder (20% protein), but can be poisonous to mono-gastric animals such as horses, pigs, poultry and rabbits if they eat only this for a long time.
- Shade
- Erosion control
- Soil improvement (when used as green manure)
- Live support for growing pepper

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#### Common name: Litchi (Vai)



Botanical Name: *Litchi chinensis* Family: **Sapindaceae** 

#### Description

- A woody, evergreen tree about 10 to 15m tall, with a short stocky trunk.
- Leaves dark green, gray white beneath. Young leaves reddish.
- Flowers small, yellowish-white.
- Fruit round with dark red rough skin. Fruit is completely covered by a translucent white, sweet aril.
- Can produce 7-8t/ha or 200kg/tree

#### **Preferred conditions**

- Light: Sun
- Altitude: 100-1,000m
- ▶ Rainfall: Annual rainfall of 1,250-1,700mm. Tolerates high humidity (80 to 90%) and drought.
- **Temperature:** 15-30°C. Requires a temperature below 15-20°C two weeks before flowering and sunshine during pollination.
- Soil: Deep alluvial sandy or clayey loam. Can grow in alluvium that is developed on sandstone and schist.

- **▶** Fruit
- Apiculture
- ▶ Tannin used for industrial purposes
- Shade
- Windbreak
- Ornamental

#### Common name: Longan (Nhan)



Botanical name: *Euphoria longana*Family: **Sapindaceae** 

#### Description

- ▶ Woody tree about 4-15m tall.
- Leaf blade oblong-ovate, dark green glossy above, lighter green beneath.
- ▶ Flowers yellow-brown
- Fruit Globular, skin smooth, thin, ranging from lightly brown to yellow. Seed Globular, black and completely surrounded with a soft, translucent white, sweet and succulent aril.
- Can produce 45-225kg/tree.

#### **Preferred conditions**

- Light: Sun
- ▶ Altitude: 100-1,000m
- ▶ Rainfall: Annual rainfall of about 1,200-2,200mm. Can tolerate drought, but water necessary for flower differentiation and fruit development.
- ▶ Temperature: 20-27°C. Cold weather not good during pollination or before harvesting.
- Soil: Many soil types Most suitable are rich alluvial or sandy soils with high humidity, moderate acidity and good drainage

- Fruit
- Seeds are used to make shampoo
- Timber used in construction, moulding and carving
- Apiculture
- Shade
- Windbreak
- Ornamental

#### Common name: Manglietia (Mo)



## Botanical name: *Manglietia glauca*Family: Magnoliaceae

#### Description

- ▶ 25-30m tall, round and straight trunk with a diameter of 30cm, light grey bark, white or yellowish wood with a smooth texture.
- Leaves egg-shaped.
- Flowers yellowish, big and grow on a stem.
- Fruit cylinder-shaped, that cracks when ripe and turns from green to gray with white spots. Seeds are black and oily with a red cover.

#### Preferred conditions

- Light: Full sun (except when young)
- Altitude: Up to 400m
- Rainfall: Annual rainfall of 1,400-2,000mm and humidity of over 80%.
- ▶ Temperature: 22-24°C
- Soil: Moist, yellow-red, humus. Will not tolerate bare hills.

#### Uses

▶ Timber for furniture, construction and artwork.

#### Common name: Mango (Xoai)



Botanical name: *Mangifera indica*Family: **Anacardiaceae** 

#### Description

- ▶ A woody tree about 10-25m tall. Bark in young trees smooth, later developing straight, longitudinal furrows
- Leaves about 15-18cm long. Young leaves reddish.
- Flowers inflorescences with ten to thousands of small flowers. Often sweet-scented, and sometimes with a less agreeable smell.
- Fruit is kidney-shaped and becomes green-yellow when mature. The pulp white, yellow or orange. The seed a rather woody to leathery endocarp.
- ▶ Can produce up to 200-300 fruits/tree/year.

#### **Preferred conditions**

- Light: Sun
- ▶ **Altitude:** Up to 1,200m in the tropics; up to 600m in the subtropics
- Rainfall: Annual rainfall of 750-2,500mm. Needs dry weather during flower budding and wet weather during fruiting. Drought tolerant.
- **Temperature:** 24-27°C (but can grow within temperature range of 5-46°C).
- Soil: Alluvial soils, but can grow on many types of soil, such as hill soil, sandy soil, or rocky soil.

- Fruit
- ▶ Timber for construction and furniture
- Shade
- Ground cover
- Medicine
- Apiculture

#### Common name: Mulberry (Dau)



Botanical name: *Morus alba* Family: **Moraceae** 

#### Description

- Perennial shrub/tree up to 2-3m tall.
- Leaves have three lobes.
- Flowers inconspicuous catkins.
- Fruits small red or dark red berries.
- Description Can produce 4,000-7,000kg/ha of fruit. Leaves can be harvested for raising silkworms six to seven months after planting. Harvest leaves once in spring, four to five times in summer, once in autumn and once at the beginning of winter.

#### Preferred conditions

Light: SunAltitude: N/A

Rainfall: N/A

▶ Temperature: 18-25°C, but can grow within the range 15-38°C. Needs humidity of around 70-75%.

▶ Soil: Alluvial soil near springs, rivers or in valleys.

- Medicine (used to treat coughs, asthma, fever and high blood pressure)
- Leaves provide food for silkworms
- Fruit

Common names: Orange (Cam), Mandarin (Quyt), Lime (Chanh), Pomelo (Buoi)



Botanical names: Citrus aurantium, Citrus reticulata, Citrus medica, Citrus grandis

Family: Rutaceae

#### Description

#### Orange

▶ Evergreen tree up to 10m tall, with dark green, glossy, oval leaves, paler beneath with or without spines. Smooth, greyish trunk and branches and very fragrant flowers. Fruits range from dark green, to yellow and orange with many sections of juicy fruit.

#### Mandarin

Small evergreen tree up to 6m tall, with glossy leaves, fragrant flowers and bearing fleshy fruit. Fruits range from yellow, red to yellow green with many sections.

#### Lime

Small evergreen tree up to 4.5m tall, with stiff, sharp spines, smooth egg-shaped leaves, and small, white fragrant flowers. The sour fruit is a pale green colour.

#### Pomelo

- Evergreen tree, often over 10m tall, with glossy, aromatic leaves and large yellow fruits.
- Trees grown from graft can provide fruit after one year. Yield varies with species and variety.

#### Preferred conditions

- Light: Dappled shade
- ▶ Altitude: 900-1,500m
- Rainfall: Annual rainfall of about 1,000-1,500mm (orange) and 1,500-2,000mm (mandarin). Lime and pomelo also grow within these ranges. These species grow well with a humidity of about 70-80%.
- Temperature: 25-27°C. Can grow at temperatures ranging from 12-39°C.
- Soil: A thick (at least 0.8m) layer of alluvial topsoil is best. The soil should have good drainage.

- Fruit
- Aromatic oil used in the food industry
- Medicine (used to treat coughs, colds and heart disease)
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#### Common name: Papaya (Du du)



Botanical Name: *Carica papaya*Family: Caricaceae

#### Description

- A fast-growing tree 3-4m tall, containing white latex in all parts. The stem is unbranched, and has prominent leaf scars.
- Leaves deeply lobed.
- Male and female flower often found on separate trees. Male flowers grow in bunches on small, branched stalks and are small and light yellow. Female flowers are solitary or grow in few-flowered bunches and are yellow-green.
- Trees with both female and with male and female flowers, but not those with only male flowers, provide fruits.
- ▶ Fruit is fleshy and cylindrical. The skin is thin, smooth, yellowish or orange when ripe. The flesh is yellowish to red-orange, sweet, with a mild and pleasant flavour. Seeds are numerous and globular, black or grayish.
- Can produce up to 34kg of fruit/tree/year.

#### Preferred conditions

Light: Sun

Altitude: 1,000m

- ▶ Rainfall: Annual rainfall of 1,200-1,500mm (distributed evenly throughout the year). Cannot resist waterlogging.
- Temperature: 21-33°C. Stops growing if temperature falls below 15°C. Hoarfrost can destroy the tree quickly.
- ▶ Soil: Light, well-drained and rich in organic matter.

#### Uses

- **Fruit**
- ▶ Green papaya used as a vegetable
- All parts of the tree contain papain, a chemical that tenderises food
- Medicine (used to treat digestive ailments and gangrenous wounds)

- SECTION THREE: AGROFORESTRY SPECIES -

#### Common name: Pepper (Hat tieu)



Botanical name: *Piper nigrum*Family: **Piperaceae** 

#### Description

- Perennial, woody vine about 3-10m long. Strong ramification with many internodes. Bark dark brown or green-brown.
- Leaves heart-shaped with long stems, dark green and glossy above.
- Flowers grow on short stalks of 20-60 flowers. Flowers yellow or light green.
- Fruit is a spherical berry containing one hard seed.
- Will produce two crops a year after four to five years.

#### Preferred conditions

- Light: Dappled sun when young, increased sun when mature.
- Altitude: Up to 800m
- Rainfall: Annual rainfall of about 2,000-3,000 mm. Soil and air humidity should be 75-90%.
- ▶ Temperature: 25-27°C
- Soil: Deep (80-100cm), soft basalt or alluvial soils with good drainage. Will grow on many soil types.

#### Uses

- Spice (seeds)
- Medicine (used to treat digestive disorders, toothache and colic)

#### **Propagation**

A support pole is needed for the pepper to grow upwards. A support tree should be established prior to growing the pepper. This support tree should be about 4-4.5m high. Sow the seeds in two holes, one on each side of the living support. Plant some trees along the boundary of the area growing pepper as a windbreak.

#### Harvesting

Harvest fruits when ripe (dark skin) to make white pepper and when not ripe (dark green skin) to make black pepper.

#### Common name: Persian lilac (Xoan ta)



Botanical name: *Melia azedarach*Family: *Meliaceae* 

#### Description

- A deciduous tree, up to 40m tall and 30-60cm in diameter with spreading branches and hemispherical crown. Grey or brown bark.
- Leaves 20-40cm long, with lance-shaped leaflets, saw-toothed edged, dark green above and paler below. Deciduous in winter.
- Flowers white and pink-purple, fragrant and numerous on slender stalks.
- Fruits found in clusters, fleshy and 1cm in diameter. Fruit turns yellow when mature. Hard seeds.
- Seed germination can take up to two months.

#### **Preferred conditions**

- Light: Full sun
- Altitude: Up to1,800m
- Rainfall: Annual rainfall of 350-2,000mm
- ▶ Temperature: 23-27°C
- Soil: Deep fertile sandy loams are best. Suited to a range of soils, even poor soil.

- Light timber used for construction and furniture
- Fuel
- Soil improvement
- Pesticide (leaves)
- Insecticide (fruit)
- Medicine (fruits used as an antiseptic to treat scabies)
- Fodder
- Shade
- Ornamental

#### Common name: Persimmon (Hong)



Botanical name: *Diospyros kaki*Family: **Ebenaceae** 

#### Description

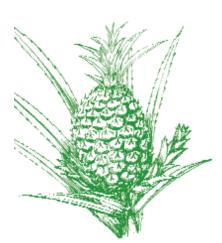
- A woody, deciduous tree about 7-15m tall.
- Leaves shiny, dark green.
- Inflorescences of flowers or solitary flowers greenishyellow.
- Fruits globular and yellowish-green to red. One fruit may have up to ten seeds. Seeds ovoid-oblong, flattened on one side.
- Can produce 150-250kg/tree after three to four years.

#### **Preferred conditions**

- Light: Eight to nine hours of sun per day.
- ▶ Altitude: 100-1,500m
- Rainfall: Annual rainfall of about 1,200-2,100 mm. Drought tolerant and can withstand wet conditions.
- Temperature: 10-22°C. High temperature is needed for the tree to blossom and develop fruits. The tree is deciduous during winter.
- Soil: Most suitable soil is heavy, sandy or stony. Can grow in many soil types.

- **▶** Fruit
- Medicine (used to treat high blood pressure)
- ▶ Timber for furniture

#### Common name: Pineapple (Dua)



Botanical name: *Ananas comosus*Family: **Bromeliacea** 

#### Description

- A herbaceous plant about 0.5-1.5m tall.
- Leaves sword-shaped, up to 1m long, 5-8cm wide; margin spiny or nearly smooth and fibrous; powdered or hairy beneath.
- Inflorescence compact, with up to 200 reddish-purple flowers; petals light green or red.
- Fruit formed by the fusion of the small berry-like individual fruits. Fruits cylindrical, fleshy, pale to golden yellow, usually seedless.

#### Preferred conditions

- Light: Diffuse light, but not too dark.
- Altitude: 1,400-1,700m is best for sweetness, but can also grow at sea level.
- ▶ Rainfall: Annual rainfall of about 1,000-2,000mm. Can tolerate drought.
- Temperature: 29-31°C. Can tolerate a wider range but root growth stops when temperature is below 10°C and above 39°C. Does not tolerate frost and the fruit is sensitive to sunburn.
- Soil: Well-drained sandy loam, but can grow in all soil types except alkaline soil.

- Fruit
- ▶ Fabric (leaves)
- Erosion control when grown on contour

#### Common name: Rambutan (Chom chom)



Botanical name: Nephelium lappaceum

Family: Sapindaceae

#### Description

- ▶ Woody tree about 4-7m tall.
- Leaflets egg-shaped, glabrous or sometimes slightly hairy on the midrib.
- ▶ Inflorescence whitish, yellowish or greenish.
- Fruit yellow to purplish-red. The seed covered by a thick, juicy, white to yellow, translucent flesh.
- ▶ Some varieties can produce 50-150kg/tree/yr.

#### Preferred conditions

- Light: Sun
- Altitude: Up to 600m
- ▶ Rainfall: Annual rainfall of over 2,500mm
- ▶ Temperature: 27°C
- ▶ Soil: Deep, well-drained soils of fertile sandy loam or clay loam.

- Fruit
- Medicine (used to treat stomachache, headache and diseases of the tongue)
- Dye (green or black) for silk (young shoots and fruit)
- ▶ Timber for construction
- Ornamental

#### Common name: Rattan (May nep)



Botanical name: Calamus tetradactylus Family: Arecaceae

#### Description

- ▶ Climbing tree up to 30m long. Stem ranges from 5-20mm in diameter.
- Leaf about 80cm long. Leaf-sheath dull green with many spines.
- Inflorescence borne on the leaf-sheath, and growing to 1m. Flowers small, yellow, and fragrant.
- Ripe fruits small, spherical and about 0.6cm in diameter, containing one seed, and covered with 21-23 vertical rows of whitish-yellow scales. Seeds are globular and dark green.
- ▶ Can produce up to 5,000 fruits/tree.

#### **Preferred conditions**

- Light: Dappled sun for the first four years. Later, rattan needs more light.
- ▶ Altitude: 200-500m
- ▶ Rainfall: Annual rainfall of over 800mm
- ▶ Temperature: Over 20°C
- Soil: Soft, heavy soil with a high humus concentration and good drainage.
- Growth: After planting can be harvested annually after three to four years. In the forest, rattan can be harvested when the tree is about ten years old and can be harvested every two years.

- Furniture and artwork (stems)
- **▶** Fruit
- Living fence

#### Common name: Ruzi grass (Co ruzi)

#### Description

- A perennial grass with sprawling stem, 1.2-1.5m tall.
- Bunched roots.
- Leaves long and covered by soft hairs.
- Fast growing, especially in the rainy season (good early wet season growth for eight weeks after the opening rains).
- Can produce 60-90t/ha/year of fresh material.



- Light: Tolerant of shade
- Altitude: Up to 2,000m
- Rainfall: Annual rainfall of 1,000+mm.
- ▶ Temperature: 28-33°C
- Soil: Highly fertile soils, such as latisols. Will tolerate acidic soils. Needs good drainage and prefers sloped land (15 degrees).

#### Uses

- ▶ Fodder (raw protein 12-13%, raw fibre 27-29%, total minerals 10-11% and dry starch 32-35%)
- ▶ Erosion control



Botanical name: **Brachiaria ruziziensis** Family: **Graminae** 

#### Common name: Sapodilla (Hong xiem)

#### Description

- Evergreen, woody tree 5-20m tall, with milky latex found in all parts. Bark rough, dark brown.
- Leaves glabrous, dark green.
- ▶ Flowers solitary, brown and hairy outside.
- Fruit rounded; skin thin, dull reddish to yellow-brown in colour, with a sandy texture. Flesh juicy, soft, yellow to red-brown in color and sweet. Seeds (up to six) oblong and brown or black in color.
- Can produce 90-180kg/tree after two to four years.



- Light: Sun
- ▶ Altitude: Up to 2,500m
- ▶ Rainfall: Resistant to drought. Tolerates strong winds.
- **▶ Temperature:** 26-30°C, but can withstand cold.
- Soil: Rich, well-drained, sandy loam. Also, tolerates saline soils.

Uses

- **Fruit**
- Latex used for chewing gum, dental surgery, etc.
- Medicine (used to treat diarrhea and fever)
- Timber for furniture and carpentry.
- Antipyretic (seeds)



Botanical name: *Manilkara zapota* 

Family: Sapotaceae

- SECTION THREE: AGROFORESTRY SPECIES -

Common name: Star apple (Vu sua)

#### Description

- Evergreen tree up to 30m tall, with white, gummy latex
- ▶ Leaves oblong 5-16cm x 3-6cm, leathery, reddish color on both sides, glabrous above.
- ▶ Inflorescence with 3-35 clustered yellowish to purplishwhite small flowers.
- Fruit 5-10cm in diameter, purplish-brown or yellowish-green; skin thin and glossy. The flesh purple or white, soft and juicy. Seeds are purplish-black.
- Can produce 60kg/tree/yr.



Light: Full sun

Altitude: Up to 400m

Rainfall: Drought can reduce the yield

**▶** Temperature: Susceptible to frost

Soil: Grows successfully in almost all types of soils but prefers well-drained and slightly acidic soils.

#### Uses

- Fruit
- Medicine
- ▶ Timber for construction
- Ornamental



Botanical name: Chrysophyllum cainito

Family: Sapotaceae

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#### Common name: Tea (Tra)



Botanical name: *Camellia sinensis)*Family: **Theaceae** 

#### Description

- ▶ Evergreen shrub or woody tree up to 10m tall. (When cultivated, the tree is pruned to about 2m.)
- Leaves dark-green.
- ▶ Flowers large, white, and fragrant.
- ▶ Fruits have three sections each containing one seed.
- ▶ Can produce 1,200-2,250kg/ha.

#### **Preferred conditions**

- Light: Dappled sun
  Altitude: 100-500m
- Rainfall: Annual rainfall of about 1,500mm
- ▶ Temperature: 15-29°C
- **▶** Soil: Deep, acidic, well-drained soil.

- Drink
- Medicine (used to treat nerve and brain-related diseases and dysentery)
- Erosion control

Common name: Tung (Trau)



Botanical name: *Aleurites montana*Family: **Euphorbiaceae** 

#### Description

- Deciduous, medium-sized tree, 12-15m tall, diameter of up to 30cm. Round, straight trunk with smooth, brownish bark and milky sap.
- Leaves lobed, 8-20cm long, 6-18cm wide. Young leaves red-brown with soft white hairs covering both surfaces, later becoming rough.
- Flowers white or pinkish, 2.5-3cm in diameter.
- Fruits globular, 3-5cm in diameter, and with three grooves, each containing one seed.
- Trees begin bearing after two to five years, with maximum production reached in eight years and continuing for 40 years. Trees yield about 45-68kg/yr of nuts, these yielding about 35-40% oil.

#### **Preferred conditions**

- Light: Full sun
- Altitude: Up to 1,500m
- Rainfall: Annual rainfall of 870-2,000mm, humid-
- ity of 85-90%.
- Temperature: 14-26°C
- Soil: Fertile, alluvial soil
- Growth: Fast-growing. Strong natural regeneration on cultivated lands and in limestone areas.

- Pulp production
- Firewood
- Oil used for soap and paint and as a lubricant
- ▶ Fuel (fruit covers)
- Oil processing scraps used for livestock food and for green manure
- ▶ Shade (for example, for tea or coffee)

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#### Common name: Vetiver grass



## Botanical name: *Vetiveria zizanioides*Family: **Graminaceae**

#### Description

- ▶ Tall, perennial grass growing in tufted clumps.
- Leaves stiff, reaching 1m long.
- Flowers purple, though some cultivated varieties do not flower.
- Fast-growing.

#### **Preferred conditions**

- Light: Full sun
- ▶ Altitude: 300-1,250m
- ▶ Rainfall: 500-5,000mm. Will survive total drought, but normally requires a wet season of at least three months.
- ▶ Temperature: 18-25°C
- Soil: Sandy loams to clay soils, strongly acid to slightly alkaline soils.

- ▶ Erosion control
- Fodder
- Oil for perfume
- ▶ Thatching
- Weaving of mats

#### Common name: White Hoary Pea (Cot khi)



Botanical name: *Tephrosia candida*Family: **Papilionoideae** 

#### Description

- A woody, evergreen shrub 2-3m tall, covered with yellowish hairs. Canopy branched and thick.
- Roots have many nodules for nitrogen fixation.
- Leaves blue-green, slightly hairy underneath, 3-7cm long.
- Flowers white.
- Fruit a hairy pod about 8-10cm long and 8-9mm wide, with black-brown seeds.
- Seeds germinate within five to seven days of sowing.
- In favourable conditions, can produce about 30t of raw biomass/ha every five months.

#### **Preferred conditions**

- Light: Full sun
- Altitude: Up to 1,600m
- ▶ Rainfall: Annual rainfall of 700-2,500mm, and a dry season of up to four months.
- ▶ Temperature: 18-28°C
- Soil: Wet, spongy, acidic, well-drained. Will grow in poor soil with a thick surface layer and also in soil that is rocky and degraded. Will not grow in flooded or salty soil.

- Fodder for pigs and cattle
- Fuel
- Insecticide
- Shade
- ▶ Soil improvement (when used as green manure)
- Erosion control

#### A P P E N D I C E S

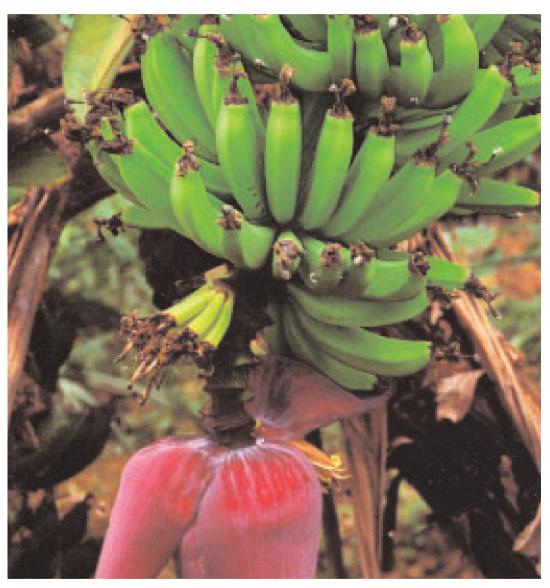


Photo above: Field planted with pineapple and fruit trees with a boundary planting of bamboo, eucalyptus and *Acacia mangium* 

#### A P P E N D I X A

#### Species Use and Planting Requirements

COMMON NAME (ENGLISH)	COMMON NAME (VIETNAMESE)	BOTANICAL NAME	AGROFORESTRY TECHNOLOGY
Acacia	Keo tai tượng	Acacia mangium	BLF, IF, WL, SI
Apricot	Mo	Prunus mume	FO, T, HG
Avocado	Во	Persa americana	FO, T, HG
Bamboo	Luồng	Dendrocalamus membranaceus	WL, BLF
Banana	Chuối	Musa sinensis	T, HG, CVS, FO
Benzoin	Bồ đề/Cánh kiến trắng	Styrax tonkinensis	WL, BLF, HG, T
Black wattle	Keo lá tràm/Keo bông vàng	Acacia auriculiformis	BLF, IF, WL, SI
Calliandra	Muồng hoa pháo	Calliandra calothyrsus	AC, CR, CVS, BLF, IF
Cashew	Điều	Anacardium occidentale	HG, T, FO
Cassia	Muồng đen	Senna siamea	BLF, WL, SI
Chickrassy	Lát hoa	Chukrasia tabularis	WL
Chinese olive	Trám trắng	Canarium album	WL, SI, BLF
Cinnamon	Quế	Cinnamonium cassia	WL, HG
Coconut	Dừa	Cocos nucifera	T, HG, FO
Coffee	Cà phê	Coffea sp.	HG, T
Custard apple	Na	Annona squamosa	FO, T, HG
Durian	Sầu riêng	Durio zibethium	FO, T, HG
Flemingia	Đậu công /Đậu ma	Flemingia macrophylla	AC, CR, CVS, IF
Guava	Ői	Psidium guajava	FO, T, HG
Guinea grass	Cỏ ghi	Pannicum maximum	CR, CVS, FB
Jackfruit	Mít	Artocarpus heterophyllus	FO, T, HG
Japanese pagoda tree	Hòe	Saphora japonica	HG, T, IF
Java almond	Trám đen	Canarium nigrum	WL, SI, BLF
Leucaena	Keo đậu	Leucaena Leucocephala	AC, CR, CVS, BLF, IF, WL
Lime	Chanh	Citrus medica	FO, T, HG, CVS
Litchi	Vải	Litchi chinensis	FO, T, HG
Longan	Nhãn	Euphoria longana	FO, T, HG
Mandarin	Quýt	Citrus reticulata	FO, T, HG, CVS
Manglietia	Mõ	Manglietia glauca	WL, SI, T
Mango	Xoài	Mangifera indica	FO, T, HG
Mulberry	Dâu	Morus alba	T, BLF
Napier/Elephant grass	Cỏ voi	Pennisetum purpureum	CR, CVS, FB
Orange	Cam	Citrus auriantium	FO, T, HG, CVS
Papaya	Đu đủ	Carica papaya	HG, T, FO
Peach	Đào	Prunus persica	FO, T, HG
Pepper	Hạt tiêu	Piper nigrum	HG, T
Persian lilac	Xoan ta	Melia azederach	BLF, WL, SI
Persimmon	Hồng	Diospyros kaki	FO, T, HG
Pigeon pea	Đậu thiều Ấn Độ/Đậu thiều	Cajanus cajan	AC, CR, CVS, BLF, IF
Pineapple	Dứa	Ananas comosus	T, CR, CVS, HG
Pomelo	Bưởi	Citrus grandis	FO, T, HG
Rambutan	Chôm chôm	Nephelium lappaceum	FO, T, HG
Rattan	Mây nếp	Calamus tetradactylus	BLF
Ruzi grass	Cỏ ruzi	Brachiaria ruziziensis	CR, CVS, FB
Sapodilla	Hồng xiêm	Achras zapota	FO, T, HG
Star apple	Vú sữa	Chrysophyllum cainito	FO, HG, T
Tea	Chè	Camellia sinensis	SI, HG
Tephrosia _	Cốt khí	Tephrosia candida	AC, CR, CVS, BLF, IF
Tung	Trầu	Aleurites montana	SI, WL

<u>Technology:</u> AC= Alley cropping; BLF=Boundary Living Fence; CR=Contour Ridge; CVS=Contour Vegetation Strip; FB=Fodder bank; FO=Fruit Orchard; HG= Home garden; IF=Improved Fallow; SI= Systematic Interplanting; T= Taungya; US= Under Sowing; WL=Woodlot. <u>Planting/propagation method</u>: B=Budding; BU= Bulbils; CT= Cutting; DS= Direct sowing; G = Grafting; L= Layering;

PLANTING/ PROPAGATION METHOD	SEED TREATMENT	SEEDS/ HOLE	SEEDS/ KG	SPACING FOR ORCHARDS
NS	3	N/A	80,000	N/A
L, G	N/A	N/A	N/A	M
G, DS	0	2 to 3	N/A	M, L
CT	N/A	N/A	N/A	N/A
BU	N/A	N/A	N/A	S
DS, SB	2	5 to 6	7,200	N/A
NS, SB	3	N/A	55,000	N/A
DS, NS, SB	2	5	19,000	N/A
NS, G, L	2	N/A	200	S
NS	3	1	33,000	N/A
SB	2	1	100,000	N/A
NS	1	1	530	N/A
SB	1	1	2,150	N/A
SB	N/A	N/A	N/A	L
SB, NS	1 with lime liquid	N/A	3,750	N/A
SB	0	N/A	N/A	S
G, B	N/A	N/A	N/A	M, L
DS, SB	2	2 to 3	50,000	N/A
L, G, DS	N/A	N/A	N/A	M
SL	N/A	N/A	N/A	N/A
NS, G, CT	0	N/A	N/A	L
NS, SB, SU, CT	2	N/A	12,000	N/A
NS, DS	2	1	270	N/A
NS, DS	2	2 to 5	18,850	N/A
L, G, CT	N/A	N/A	N/A	S
L, G	N/A	N/A	N/A	M
L, G	N/A	N/A	N/A	M
L, G, CT	N/A	N/A	N/A	S
SB	1	1	25,200	N/A
L, G, DS	N/A	N/A	N/A	L
CT	N/A	N/A	N/A	N/A
SL	N/A	N/A	N/A	N/A
L, G, CT	N/A	N/A	N/A	S
DS, NS	2	3 to 5	N/A	S
L, G	N/A	N/A	N/A N/A	M
CT, DS, SB, L	2	N/A	???	N/A
SB, DS	2	3	1,700	N/A
G, SU	N/A	N/A	N/A	M
DS, NS	0	2 to 3	9,000	N/A
SU				
	N/A	N/A	N/A	N/A
L, G, CT	N/A	N/A	N/A	M
L, G	N/A	N/A	N/A	M, L
SB, NS	2	N/A	1,300	N/A
SL	N/A	N/A	N/A	N/A
L, G	N/A	N/A	N/A	M
NS, G	0	N/A	N/A	L
CT, SB, DS	N/A	N/A	N/A	N/A
DS C	2	2 to 3	350	N/A
DS, G	0	3	270	N/A

NS= Nursery seedlings; SB = First sown in seedbed; SL= Slips; SU = Suckers. Seed treatment: 1= Cold water treatment; 2= Hot water treatment; 3 = Boiling water treatment; 4 = Scarification. Space ranges for orchards: S = Small distance among trees (about m 2-4mx2-5m), M=Medium distance among trees (about 5-7mx5-8m), L=Long distance among trees (about 8-12mx 8-12m)

#### A P P E N D I X B

#### RECOMMENDED TREE SPACING

	DIRECT SOWN SEEDS		NURSERY SEEDLINGS	
	Field spacing	Plants/ha or /km	Field spacing	Plants/ha or /km
Alley Cropping:				
Flat/gentle slopes	5.4 x 0.2m	9,259/ha	5.4 x 0.4m	4,630/ha
Steep Slopes	4.5 x 0.2m	11,111/ha	4.5 x 0.4m	5,556/ha
Home Gardens				
	Depends on mix of species planted			
Living Fences:				
Trees	0.2m	5,000/km	0.4m	2,500/km
Fodder/Green Manure Bank:				
Pure Stand of Trees	0.9 x 0.45m	24,691/ha	0.9 x 0.9m	12,346/ha
Intercropped Trees w/ Napier	4.5 x 0.2m	11,111/ha	4.5 x 0.4m	5,556/ha
Intercropped Napier w/ Trees	NA	NA	0.9 x 0.45m	24.691/ha
Woodlot				
Poles	1.8 x 0.9m	6,173/ha	1.8 x 1.8m	3,086/ha
Small - Medium Trees	1.8 x 1.8m	3,086/ha	3.6 x 1.8m	1,543/ha
Large Trees	3.6 x 1.8m	1,543/ha	3.6 x 3.6m	772/ha
Contour Vegetation Strip:*				
Grass	NA	NA	0.15m	6667/km
Trees	0.2m	5,000 km	0.4m	2,500/km
Systemic Tree Intercropping:				
	10 x 5m	200/ha	10 x 10m	100/ha

<sup>\*</sup> Distance between grass strips varies from 20m on gentle slopes to 5 m on very steep slopes

<sup>-</sup> THE AGROFORESTRY FIELD GUIDE: A TOOL FOR COMMUNITY BASED ENVIRONMENTAL EDUCATION -

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- SECTION THREE: AGROFORESTRY SPECIES -