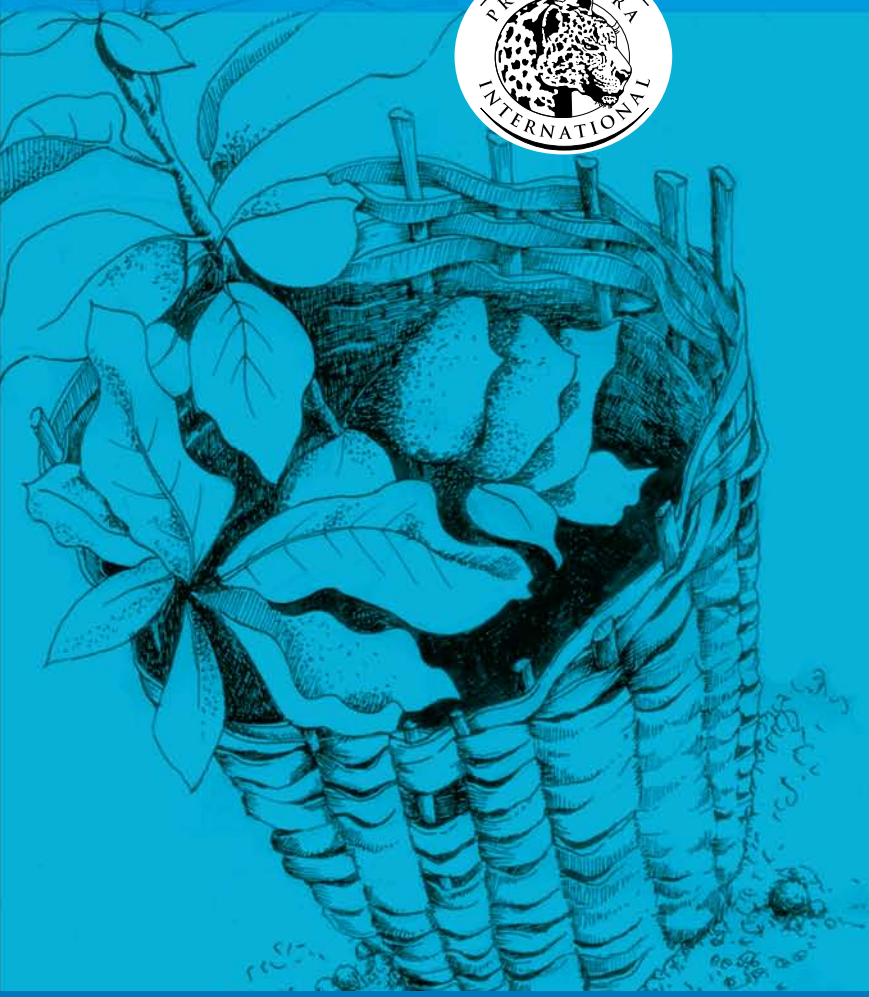
AGROFORESTRY GUIDE



Experiences from farmer trainings in Ghana,

A University of Ghana / Leventis Foundation partnership

AGROFORESTRY GUIDE

Experiences from farmer trainings in Ghana,
A University of Ghana / Leventis Foundation partnership

Printed by

Editors and Contributors

- Mr. Wilfrid Pineau
  e-mail: wilfrid.pineau@wanadoo.fr
- Dr. Tsatsu Adogla-Bessa
  e-mail: tabessa@ug.edu.gh

Staff Editor

Petra Bakewell-Stone[1]
e-mail: petra@pronatura.org

Contributors[2]

- Prof. Anna Reynolds Barnes
- Mr. Richmond Tegbe
- Mr. Ebenezer Budu-Biney
- Mr. Felix Sarkwa
- Mr. Isaac Amanor
- Mr. Jacobus Amoah

Illustrator

Joëlle Cancelier
e-mail: jochari@libertysurf.fr

Acknowledgements

We sincerely thank the Leventis Foundation (London), the French Ministry of Foreign Affairs and the Agence Française pour le Développement who sponsored this work. In addition we are also very grateful to:

- Ms. Georgina Dimopoulou
- Mr. Anastasios Pavlos Leventis, CBE, OFR
- Mr. Phil Hall, OBE
- Prof. Benjamin K. Ahunu
- Prof. Kwame Afreh-Nuamah
- Mr. Guy F. Reinaud
- Mr. Franck de Rouville
- Mr. Babatunde Akinsinde
- Mr. Adam Al-Hassan
- Mr. Adam Mahama

[1] Pro-Natura International, Paris, France
[2] University of Ghana / Pro-Natura International Ghana

PREFACE

The A.G. Leventis Foundation agricultural training schools in Nigeria and Ghana were established to train young farmers in the theory and practice of an agronomy which encourages the maintenance of soil fertility. A major weapon in this battle to achieve sustainability on the small and medium scale farm in West Africa, is the idea of combining and using agroforestry techniques as an integral part of any farmers programme and this is the reason why the Foundation invited Pro-Natura International as an advisor and participant in its schools programmes.

It is therefore a matter of great satisfaction to us that the new agroforestry guide for Ghana, achieved as a result of a collaboration between the University of Ghana, Legon, and the Pro-Natura International Ghana team, under the leadership of M. Wilfrid Pineau, is now completed and ready for distribution. It is intended that this guide will be issued to all trainees and ex-trainees of the Leventis Foundation Farmers Training Programmes and that it should also be made available to a wider spectrum of the farming community in Ghana. Such manuals have already been published in Nigeria in 2005 and in Ivory Coast in 2009 and we can attest to the fact that, in Nigeria, the manual has been used extensively, widening the scope and options available to small and medium-scale farmers. Training in agroforestry and possession of the manual have assisted them in understanding the environmental benefits resulting from an introduction of tree crops on a systematic and well planned basis and as a supplement to their arable and animal husbandry programmes.

This is a time when the world faces ever more visible problems resulting from climate change and the degradation and erosion of soils, caused mainly by over-exploitation and the expansion of poorly-managed intensification in farming. Solutions proposed here will encourage farmers to introduce sustainable alternatives in food production. We are confident that this manual will help farmers in Ghana to improve their methods at a time when expanding population and export demand induces an increase in the value of food and of agro-based raw materials for industry, offering them the opportunity to achieve better living standards for themselves and for their families.

A.P. LEVENTIS
Chairman of the A.G. Leventis Foundation


ON - FARM
AGROFORESTRY
TRAINING-PROJECT
(BODADA BUEM)
PRO · NATURA
INTERNATIONAL
Liberté Egalité Fraternité
REPUBLIQUE FRANCAISE
FSD FRENCH EMBASSY
INTEGRI PROCEDAMUS
UNIVERSITY OF GHANA

CONTENTS

1.0. INTRODUCTION

1.1. AGROFORESTRY AS AN EMERGING SCIENCE

Agroforestry is a relatively new science that takes into account ancestral traditional practices originating mainly from tropical countries. For too long, different fields of research have been compartmentalised without regard for complementarities, for example between agriculture and forestry. From the late 1970s there was a rapid growth in research on interactions and synergies between trees, crops and animals. Then it was proved that agricultural yields are improved by having trees on-farm.

Research is a long-term process and only rarely do results genuinely benefit the local communities. Farmers in the in the majority word need practical applications that can be used directly at the local level. Agroforestry aims to establish links between different fields of research and promote applied research at farm level. Techniques then become practices that can be popularised amongst farmers on a large scale, whilst avoiding over-specialisation.

Agroforestry is situated at the interface between ecology and anthropology. In a forest, humans can hunt game, pick plants and other small organisms, without interfering too much with the environment. From time immemorial humans have been exploring forests, and started to landscape and domesticate them at a very early stage. To favour the growth of chosen plant species, microclimatic conditions were modified by cutting trees locally, notably to increase the quantity of incoming light benefiting young plants. This happened long before the domestication of species; is it possible that humans were agroforesters before they became farmers or breeders? Beyond agricultural and forestry techniques, agroforestry practices also have sociological and ethnological dimensions.

Agroforestry is a relevant option for ensuring food security and natural resource management at the community level. Agroforestry is a long-term investment and a significant tool for tackling global warming.

This agroforestry training manual is first intended for Ghanaian farmers, many of whom contributed to its writing by collaborating with the Non-Governmental Organisation (NGO) Pro-Natura International and the Institute of Agricultural Research of the College of Agriculture and Consumer Sciences, University of Ghana (Legon). To maximise exchange of knowledge and experiences, readers are encouraged to freely photocopy this publication and circulate it widely amongst actors of rural development in Ghana and other Anglophone West African countries.

1.2. PRO-NATURA COLLABORATION IN GHANA

Pro-Natura International's activities in Ghana date back to 2002 through its association with the University of Ghana's Leventis Foundation Farmer's Training Programme (LFFTP). Pro-Natura's mission is to implement development projects with local actors involved in sustainable agriculture, conservation and management of natural resources, biomass energy and carbon sequestration.

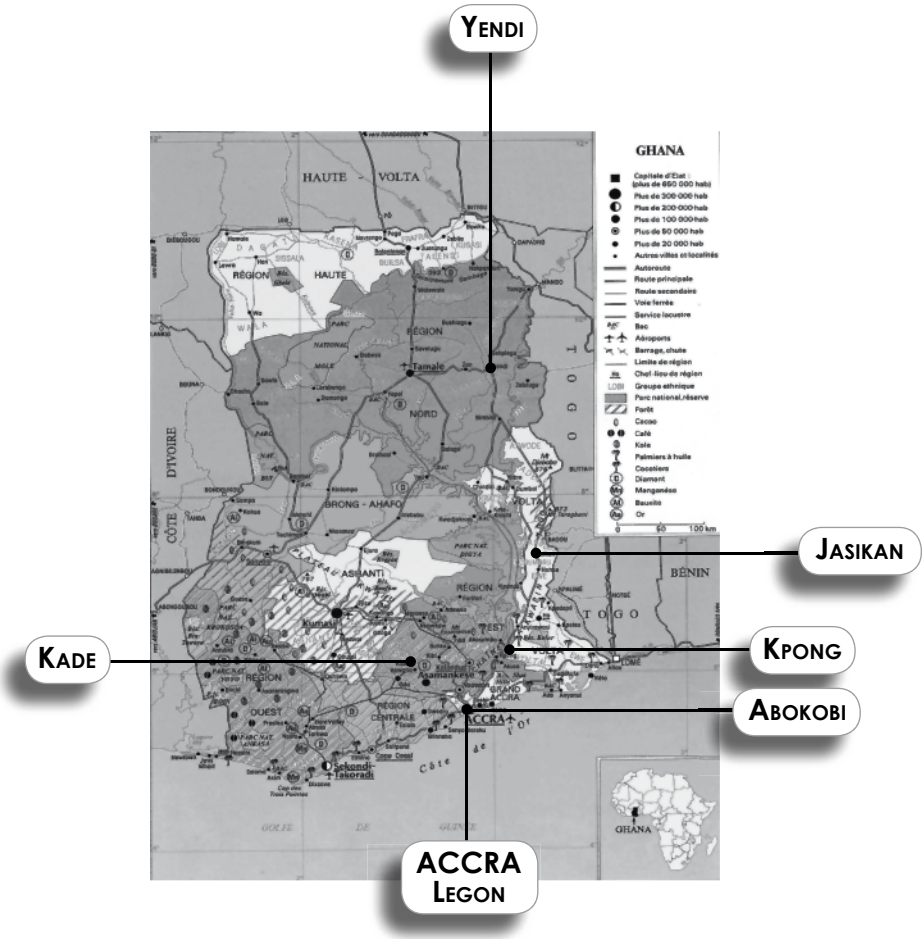
The LFFTP was established in 1990 to train practicing and would-be farmers, especially the youth and provide them with the requisite knowledge and skills to enable them to stay in rural farming communities. The annual ten-month programme is residential and fully sponsored by the Leventis Foundation, London. It is implemented by the Institute of Agricultural Research of the University of Ghana. The LFFTP operates from the Agricultural Research Centres (ARCs) of the Institute of Agricultural Research under the College of Agriculture and Consumer Sciences (CACS) located at Kade, Legon, and Kpong.

Pro Natura International (PNI), in consultation with the Leventis Foundation and University of Ghana, introduced the agroforestry programme into the LFFTP in 2002. In the same year, the on-Centre agroforestry training programme was fully incorporated into the curriculum of the training programme and began with a batch of trainees. Trainee farmers at the time were taught agroforestry practices and how to raise seedlings using the Non-Mist Propagator (NMP) and Humidity Chamber (HC) techniques. Three years later, agroforestry practices were introduced to LFFTP ex-trainees in selected rural communities.

In April 2005 Pro-Natura International Ghana (PNIG) was officially registered in Accra as a local NGO. In the same year PNIG signed a five-year Memorandum of Understanding with the University of Ghana. Subsequently, PNIG submitted a proposal to the Funds for Social Development (FSD) of the French Embassy in Accra, Ghana for a one-year project entitled "On-farm agroforestry training to improve livelihoods of small-scale farmers in Ghana". The projects were located in four different ecological zones in Ghana, namely;

FARMING COMMUNITY	REGION	ECOLOGICAL ZONE
Yendi	Northern	Savannah
Jasikan	Volta	Semi-deciduous forest
Kade	Eastern	Tropical forest
Abokobi	Greater Accra	Coastal savannah

This project benefited 60 farmers, with an emphasis on ex-trainees of the LFFTP. The aim of the project was for the farmers to diffuse the knowledge and technical know-how acquired to neighbouring farmers, improving their livelihoods in the long-term.



Locations of University of Ghana / Leventis Foundation / Pro-Natura agroforestry project sites in Ghana

In 2008, PNIG in collaboration with the University of Ghana, and with support from the French Ministry of Foreign Affairs and the Leventis Foundation started a two-year project aimed at improving the livelihoods of beneficiary cocoa farmers while improving biodiversity, particularly in cocoa plantations that represent a major deforestation agent in Ghana. Three cocoa growing communities in each of Kwabibrim and Jasikan districts were selected. The objective was to train 180 farmers in agroforestry practices in these six communities.

In Ghana new "full sun" hybrid cocoa varieties that are fast-growing and high-yielding are fast replacing the older varieties, which require shade to grow. The result is that farmers cut all other trees on their cocoa plantations, leading to a monocultural farming system with its associated negative effects: accelerated soil degradation, loss of biodiversity, loss of cultural heritage and traditional knowledge associated with Non-Timber Forest Products (NTFP). If the boom in these hybrid cocoa varieties is not accompanied by agroforestry practices, the trend will lead to massive deforestation, unsustainable agriculture, loss of valuable timber and useful species and attendant global warming.

Agroforestry systems, on the other hand, are known to have the ability to preserve endangered tree species, mammals, reptiles, and particularly birds. To promote sustainable agriculture and reconstruct biodiversity in and around cocoa plantations, the PNIG project seeks to educate and help cocoa farmers to establish agroforestry systems by planting useful trees that do not affect cocoa growth. New and innovative agroforestry systems suitable for cocoa production need to be invented.

Ultimately, PNIG is also exploring and facilitating reforestation contracts between farmer groups and timber companies to enable beneficiaries to sell their timber within a legal and secure land tenure framework. By working with different types of partners such as farmers, NGOs, Universities, applied research centres, public institutions and private companies, this initiative strengthens the agroforestry network in Ghana. ■

2.0. CONCEPT OF AGROFORESTRY

2.1. DEFINITIONS OF AGROFORESTRY

Agroforestry can be described simply as the deliberate use of trees on farmlands. More precisely, agroforestry is a collective name for land use systems where woody perennials (trees, shrubs, palms, bamboo etc.) are deliberately used on the same land management unit as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence, resulting in significant ecological and economic interactions between the different components.

Agroforestry has been defined as 'a dynamic, ecologically-based, natural resource management system that, through the integration of trees in farm- and rangeland, diversifies and sustains smallholder production for increased social, economic and environmental benefits' (Leakey, 1996).
Agroforestry as a science is different from both agriculture and forestry. Its objective is to optimise positive interactions between woody and non-woody components so that the production system may be more sustainable and diversified than conventional agricultural production systems.

These definitions of agroforestry imply that:

- Agroforestry normally involves two or more components, at least one of which is a woody perennial.
- Agroforestry systems always have two or more outputs.
- The lifecycle of an agroforestry system is always more than one year.
- Even the simplest agroforestry system is more complex ecologically and economically than a mono-cropping system.

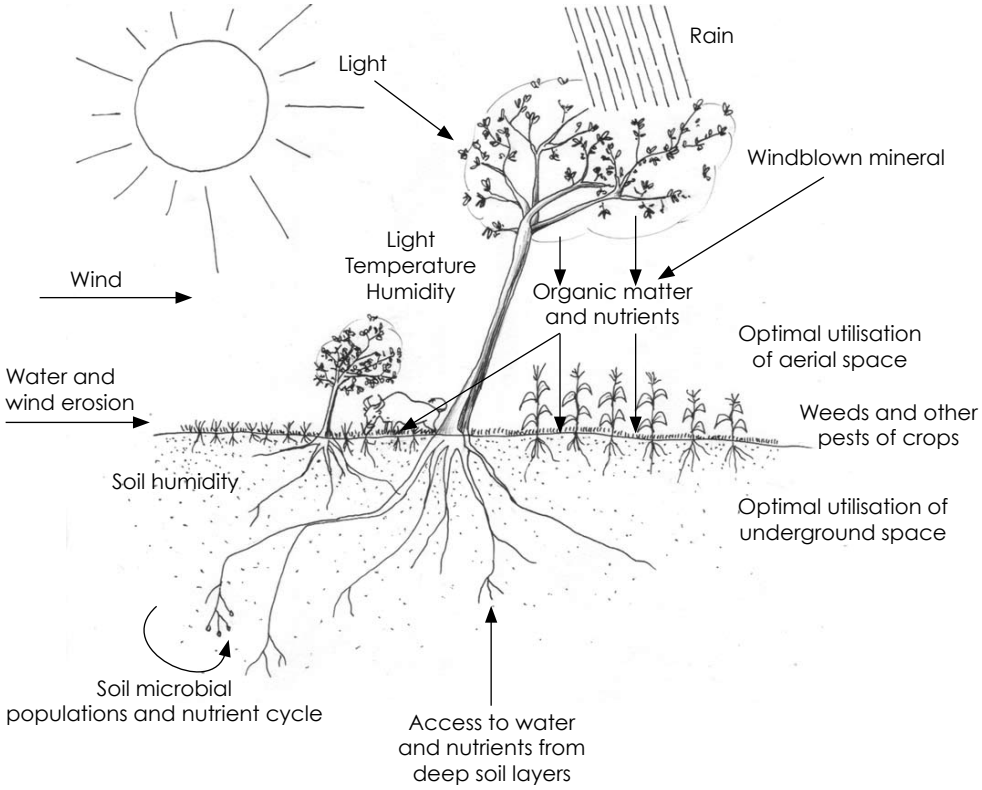
- The use of the woody perennial must be deliberate and not accidental.
- The woody and non-woody components can occupy the land management unit at the same time (simultaneously) or one after the other (sequentially).
- Each of the components (i.e. woody and non-woody) must contribute positively to the performance of the system and result in economic and ecological benefits to the farmer.

Agroforestry has higher potential benefits for smallholder farmers who live mainly from subsistence agriculture than for high input, mechanised and commercial farming. However, there are some agroforestry practices such as wind breaks, grazing in tree crop plantations and grazing in forest plantations which can be used in intensive land use systems on a large scale.

2.2. AREAS OF ECOLOGICAL INTERACTION IN AGROFORESTRY

In order for an agroforestry practice to be beneficial, there must be a positive effect on the entire land use system through ecological and economic interactions amongst the components. These interactions can be positive, negative or neutral. The interaction is complementary if the presence of one component increases the yield of other. The aim of agroforestry is to identify positive interactions and maximise them while trying to reduce negative interactions.

The main ecological interactions in agroforestry are climate (light, temperature, humidity, rainfall, wind), soil (organic matter, nutrients, erosion), biological resources (plants and animals) and space available for growth. Interactions may occur continuously or sporadically throughout the seasons. Whilst they may initially be negative or neutral but they can soon become positive e.g. soil fertility has improved and erosion has been controlled through the presence of trees.



Main areas of ecological interactions in agroforestry

2.3. ADVANTAGES AND DISADVANTAGES OF AGROFORESTRY SYSTEMS

: : Advantages

- Increased and more sustainable crop and animal output, resulting directly from the introduction of trees or indirectly through the contribution of trees to enhanced soil fertility, and soil structure

- Enhanced microclimates through increased standing biomass, with benefits to crops, animals and people, resulting from effects of trees on microclimate

- Reduced soil erosion and siltation of waterways, achieved through the reduction and prevention of run-off on sloping land
- Reduced pressure on grazing lands through the intensification of fodder and animal production
- Higher incomes for small-scale farmers and other land users, resulting from the sale of tree products
- Reduced dependence on external sources for key agricultural inputs (fertilisers) and subsistence products (fuelwood, building materials, medicines etc.) resulting from their supply by trees
- Reduced pressure on remaining forests, achieved by raising the productivity of existing agricultural lands and by increasing the supply of fuelwood and other forest products
- Ultimately results in more efficient land use because several commodities using same land unit.

: : Disadvantages

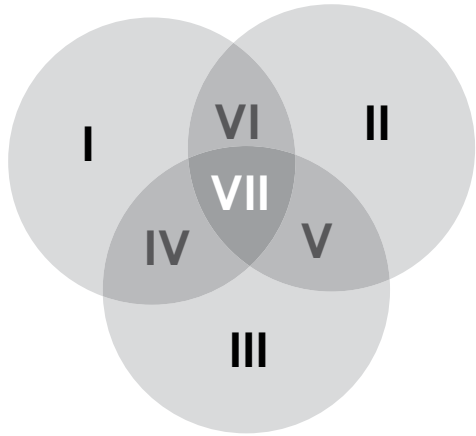
- If not carefully selected, introduced and managed, the various components compete negatively for resources such as water, light, nutrients and space.
- Woody perennials take time to establish which delays the interaction with and benefits for other components.
- Wrong choice of woody perennial species may lead to failure of trees in the ecological zone.
- When the farmer is not the landowner, permission may not be granted to plant trees.

The analysis of the three main agroforestry components, namely trees, crops and animals (or pastures) have resulted in the simplest classification of the systems based on the presence of these components as follows:

- Agrosilvicultural systems: trees and seasonal crops.
- Silvopastoral systems: trees and animals/pastures.
- Agrosilvopastoral systems: trees, seasonal crops and animals pastures.

There are also other systems such as fisheries in association with trees (aquaforestry) and combining insects with trees (entomoforestry). They are usually classified separately, although technically they belong to silvopastoral systems.

Animals must generally be physically present near trees on the same plot for a system to qualify for the suffix "pastoral". For example, an alley-cropping system whose tree biomass is used for mulch would be agrosilvicultural. It would only be considered agrosilvopastoral if the animals grazed on the plot. However this last rule is not strictly enforced. For example woody strips in cropland for fodder production are usually called silvopastoral, even if the fodder is transported to the animals. The figure below illustrates how presence of components is used to classify agroforestry:



Key: I. Agriculture ; II. Forestry ; III. Animal Husbandry IV.Agropastoralism ; V. Silvopastoralism ; VI. Agrosilviculture ; VII. Agrosilvopastoralism

Classification of agroforestry based on components

3.0. AGROFORESTRY SYSTEMS

3.1. DEFINITIONS AND CONCEPTS

A farming system can be defined as a unique and reasonably stable arrangement of farming enterprises that a household manages according to well-defined practices in response to the physical, biological and socio-economic environment, and in accordance with the households' goals, preferences and resources. Farming enterprises comprise all activities undertaken to produce an output that contributes to total production or income of the farm family. A household is a social organisation in which members normally live and sleep in the same place and share their meals.

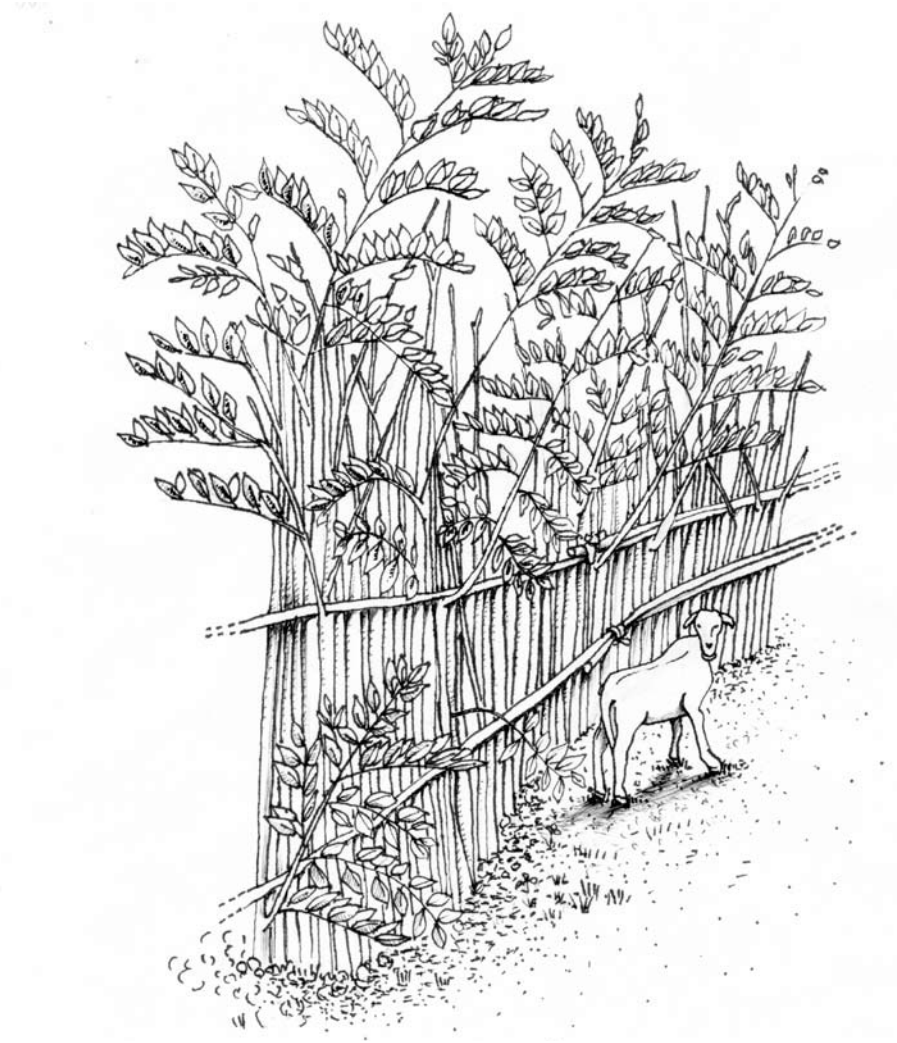
An agroforestry system is defined as a set of interdependent agroforestry components (trees with crops and/or animals) representing a current type of land use in a given region. The systems' boundaries can either be natural or artificial. The system is thus defined by the presence of certain components.
Thus in agroforestry, the term 'system' corresponds to land use types and not the output of a particular commodity as in classic farming system concept. It is because of the multiple commodities produced by agroforestry systems and due to the complex nature of agroforestry, that it is not possible to use a commodity-oriented classification for agroforestry systems.

3.2. COMMON AGROFORESTRY PRACTICES AND SYSTEMS

: : Live fences

These are lines of trees that are grown and used to delineate boundaries of farms, pasture plots, animal enclosures or general plots. Live fences are popular in areas where wood for fencing is limited and other materials like cement and iron are very expensive. The trees also provide posts, stakes and even fruits. This is a common practice in many regions as well as a very simple method used to incorporate trees into agricultural landscapes.
Live fences may be made up of single or multiple densely planted rows, and usually vigorous growing species are used. Thorny species

are popular boundary trees. Trees may also be widely spaced with wire in between the trees. Trees are regularly pruned, pollarded or coppiced depending upon the species and type of product desired.
It is important that live fences grow rapidly, at least during the first few years until they are tall and thick enough to withstand feeding by livestock and perform their barrier function. Trees may need protection and watering in the establishment phase. This implies the use of fast-growing species that are easy to establish and well adapted to the environment, such as *Gliricidia sepium*, *Acacia nilotica*, *Moringa oleifera* and *Parkia biglobosa*.



: : Alley farming

This consists of planting rows of trees on plots with annual crops grown in between the rows. One of the most popular examples is growing cereals between rows of nitrogen-fixing leguminous shrubs. Thanks to the maintenance of soil fertility, a fallow period is no longer obligatory. For example, one finds 3 -5 rows of maize between two rows of *Gliricidia sepium*. It is also known as hedgerow intercropping.

The main purpose of alley farming is to maintain or increase crop yields by improvement of the soil and microclimate through the cycling of nutrients, mulching and weed control. Other useful products like fodder may also be obtained from the trees, and on sloping land, the rows of trees may help to control erosion. The system is mostly used in humid and sub-humid tropical areas and is also most applicable where people feel a need to intensify crop production but face soil fertility problems.

The concept of alley cropping was designed to try to solve, in a spatial manner, and simultaneously to crop cultivation, soil infertility problems related to shifting cultivation and traditionally resolved by fallowing practices. Although part of the land is lost to the tree rows, this is be balanced by increased crop yield per unit area. Alley farming increases crop yields as a result of mulch from the hedges, reduced erosion and micro-climatic benefits. Hedges can also be used as fodder.

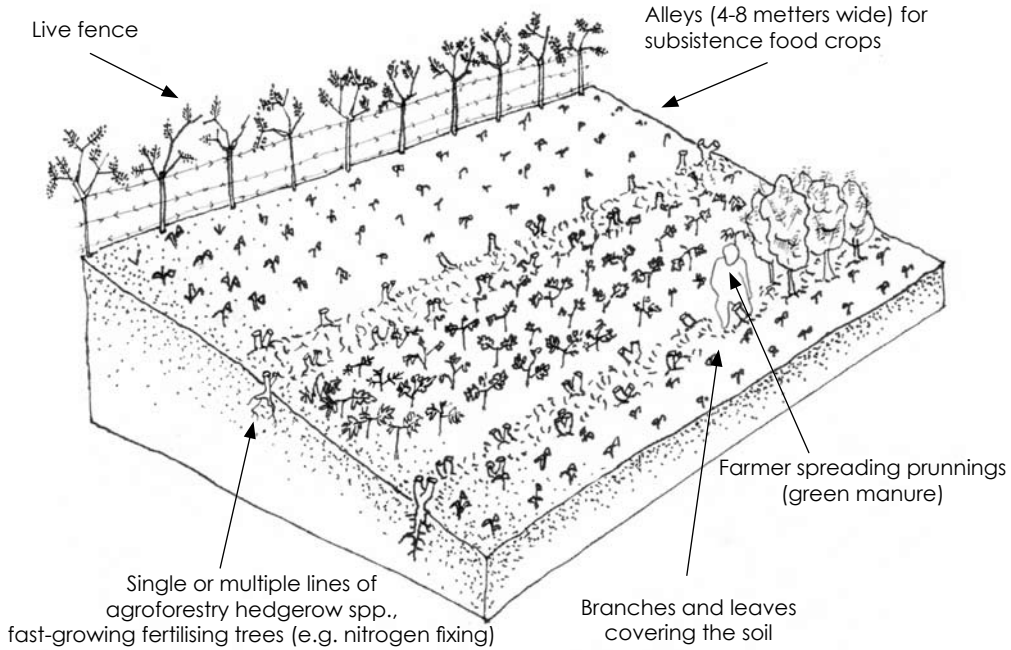
The distances between the hedges may vary according to the region, tree species, climate and soil conditions. The spacing usually ranges from 4 – 8 metres between rows of trees and 0.25 – 2 metres within rows. Closer spacing is practiced in humid areas and wider spacing in sub-humid areas. The height and width of the hedges also vary depending upon the pruning practices used on the trees during the cropping season, so that crops are not shaded. Efficient hedgerow management involves appropriate and timely pruning.

An ideal alley-farming tree should have the following characteristics:

- Light open crown that lets sunlight through;
- Ability to re-sprout quickly after pruning, coppicing or pollarding;
- A productive function that includes poles, wood, food, fodder, medicines and other products;

- Good leaf litter making nutrients available at the appropriate times in the crop cycle;
- High above-ground leaf biomass production;
- Few and shallow lateral roots;
- Ability to assist in nitrogen fixation;
- Deep thrusting tap root system;
- Contains no allelopathic chemicals in shoots and roots;
- Resistant to and not serving as a host to pests and other diseases, particularly those of crops grown in alleys;
- Resistance to drought, flooding and other climatic hazards;
- Some degree of resistance to fire.

The criteria listed above can serve as a guide for species selection at particular places. In some cases it may be necessary to combine two or more species to provide the products and services required. Examples of suitable alley farm trees are *Moringa oleifera*, *Vitellaria paradoxa*, *Senna siamea*, *Calliandra calothrysus* and *Albizia spp.*



: : Improved fallow

Improved fallow is the replacement or enhancement of natural fallow vegetation by the introduction of selected trees.

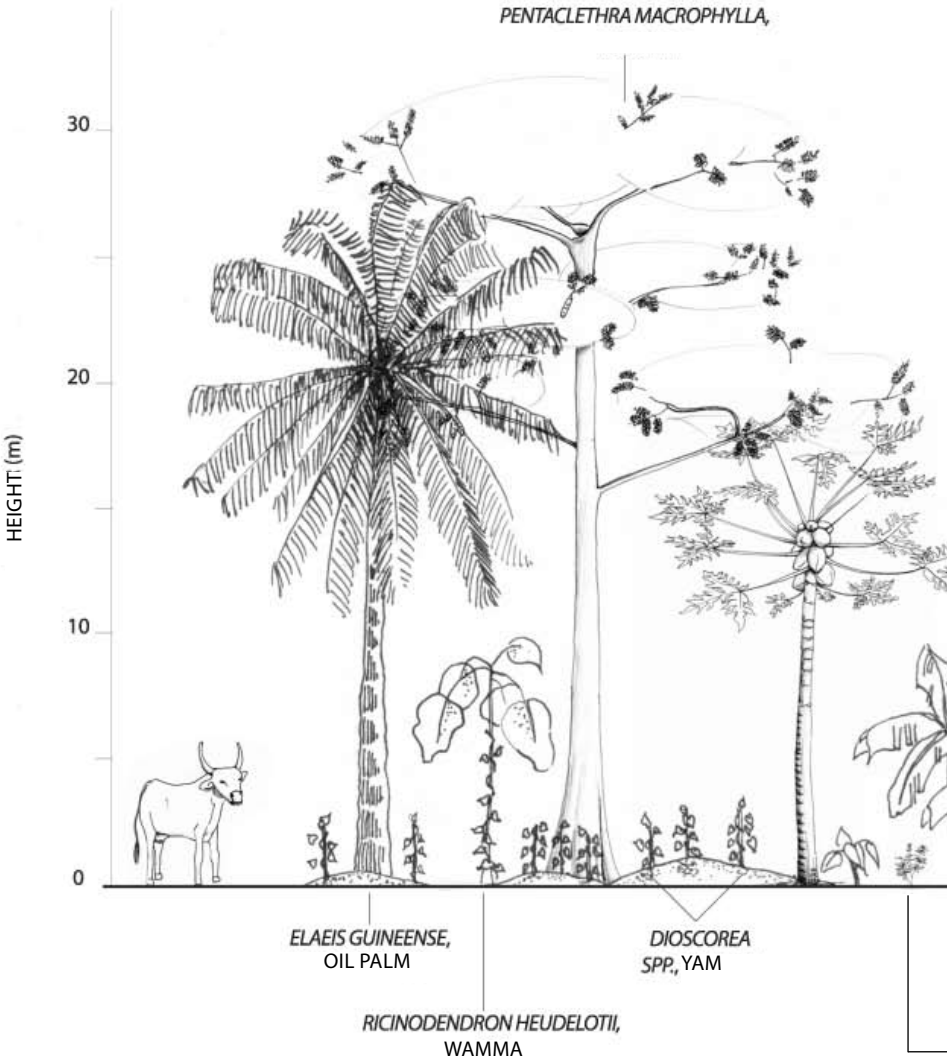
When crop rotation is alternated with a fallow period, the soil can rest and recover its fertility during the fallow period. Under population pressure and land scarcity, land cannot be left fallow for long. Improved fallow systems can shorten the fallow period and also increase yield of subsequent crops. This system is essentially an improvement on the shifting cultivation concept. In this case, instead of abandoning the plot to fallow for 5 – 7 years after a few cropping seasons, useful woody perennials are planted on the plot to simulate natural fallow regeneration. For example one can plant nitrogen-fixing trees that will establish quickly and regenerate soil faster than the spontaneous species in natural fallows. Trees that can be planted include *Acacia nilotica*, *Albizia zygia*, *Cajanus cajan* and *Gliricidia sepium*.

The system can be practiced in humid and sub-humid lowland areas. Intensive labour is required at the time of planting trees but once established, an improved fallow does not require much maintenance. The species planted will depend on the land pressure and aims of the farmer. Trees may be planted for different products like food, medicine and fodder thus making the fallow period a phase that not only re-establishes soil fertility but is also profitable.

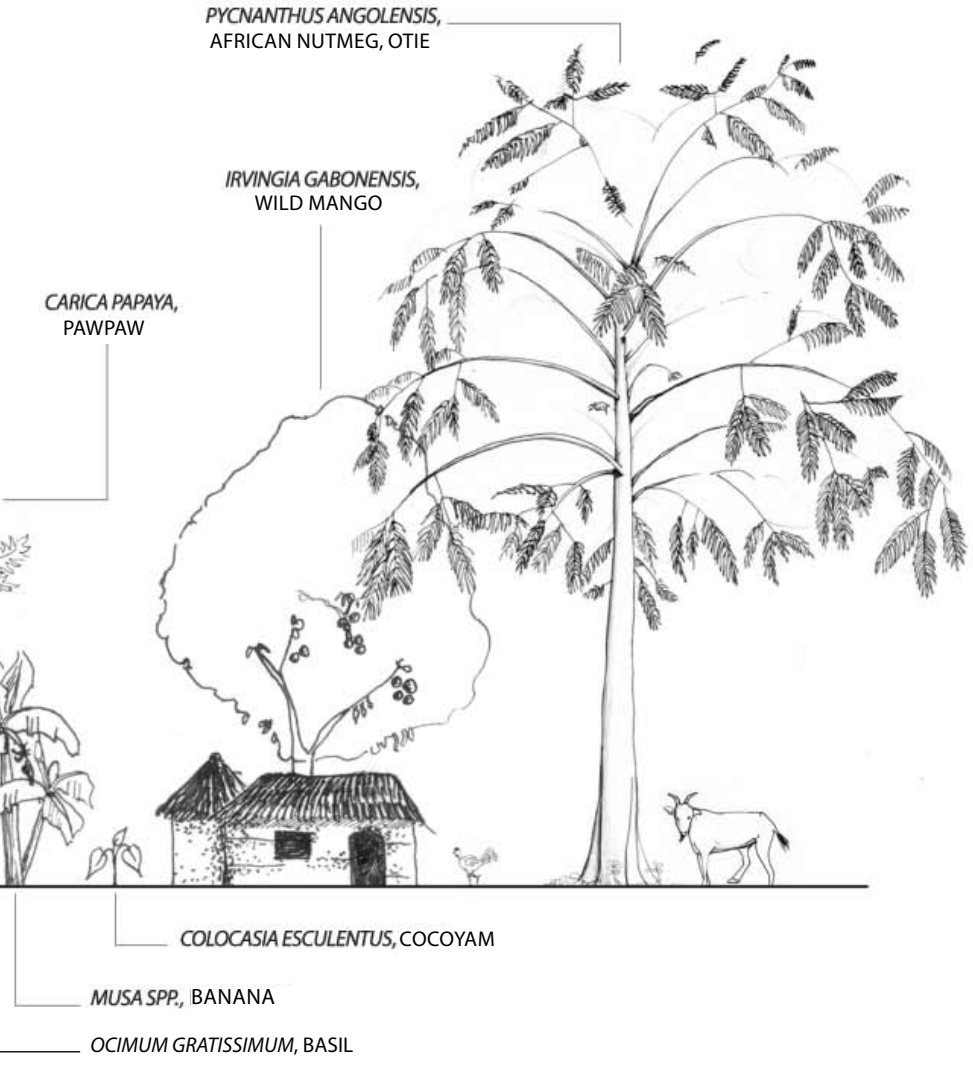
: : Home gardens

A home garden is an agroforestry practice in which mixed crops of annual crops and perennial crops (trees) are grown in combination with animals close to the homestead to supplement the staple food supplied by the field crops. It is an agrosilvopastoral system. It is often only a tiny part of the complete farm but plays a special role in that it provides daily produce.

Tree home gardens are especially well known in the humid tropics. They are small, and the carefully selected species of different sizes, types and growth cycles, together with many domesticated animals


PENTACLETHRA MACROPHYLLA,
30
20
10
0
HEIGHT (m)
ELAEIS GUINEENSE,
OIL PALM
DIOSCOREA
SPP., YAM
RICINODENDRON HEUDELOTII,
WAMMA

Home garden


PYCNANTHUS ANGOLENSIS, AFRICAN NUTMEG, OTIE
IRVINGIA GABONENSIS, WILD MANGO
CARICA PAPAYA, PAWPAW
COLOCASIA ESCULENTUS, COCOYAM
MUSA SPP., BANANA
OCIMUM GRATISSIMUM, BASIL

aim to supply the household with a continuous flow of products. They are often of great significance to smaller farms because of the buffering capacity they offer when yields are low. Home gardens are found worldwide. In some areas, however, home gardens are cultivated under semi-arid conditions. This is possible as long as the soil moisture is at a certain minimum threshold. These home gardens however show less species diversity and are less complex in structure than their humid counterparts.

The upper storey of a home garden is formed by species that produce timber, fuel wood, fruit, fodder and shade for example Mango, Tamarind and Coconut trees, reaching 20 – 40 metres high. The middle storey is about 10 metres high and consists of small trees and shrubs that tolerate some shade such as coffee, tea, banana, papaya and various fruits and spices. The under storey is up to 1.5 metres high and consists of plants like beans, pulses, root crops, legumes and grasses which can be used for human consumption or fodder.

In most cases animals are kept in home gardens. The animals can browse there and rest in the shade. Small ruminants, micro livestock and poultry may be kept both for household consumption and for sale. Too many animals can however have adverse effects on crops and trees and hence trees have to be protected or animals well controlled. Extra cash income can be generated through fishponds or bee keeping in the home garden.

A home garden in some societies is a status symbol. The higher the species diversity and the bigger the meeting space, the higher the value of the garden as a status symbol.

One constraint is that because of the high diversity of ecological niches, a home garden can provide a habitat for species that can harbour bacterial and fungal diseases and pests like reptiles, rodents, insects, etc.

: : Fodder banks

These are high quality fodder species usually legumes that are grown in high-density pure stands or in mixtures with herbaceous species example *Cajanus cajan* mixed with *Stylosanthes spp.*

They are basically animal protein banks intended primarily to supply dry season supplemental feeding. Forage may be harvested to feed livestock or animals brought in to browse directly. Livestock may have access to some or the entire paddock during use. Harvesting may be seasonal or all year. Fuelwood, stakes and medicines are some of the added products from fodder banks.

Species used should have as many of the following characteristics as possible: fast-growing; rapid regeneration; nitrogen-fixing; strong and deep tap root system; drought tolerant; cheap to establish; few diseases and pests; multiple uses like fuelwood, stakes and medicine. Examples of good fodder bank species are *Acacia albida*, *Cajanus cajan*, *Albizia spp.*, and *Sesbania sesban*.

4.0. GENERAL RECOMMENDATIONS AND SELECTION OF AGROFORESTRY TREE SPECIES

4.1. GENERAL RECOMMENDATIONS

For an agroforestry system to be a success, it is very useful:

- To judiciously select agroforestry system(s) according to the farmer's objectives and the potentials of the site: soil fertility, water availability, proximity to the village, market access, etc.;
- To prioritise multi-purpose species already naturally locally adapted;
- To prepare the site very carefully;
- To use good quality seeds, saplings and vegetative material (cuttings, rootstock, etc.);
- To start nursery activities at the appropriate period;
- To plant, protect and manage trees on the agroforestry plot very well.

The following recommendations are made to save existing trees or to reintroduce trees on-farm:

a) Flexible training of staff and supervisory staff (extensionists, agroforestry trainers, etc.) to allow for new techniques and practices to be efficiently spread amongst farmers. Focus should be on participation and ensuring that farmers are motivated, rather than trying to realise standardised models that have not been adapted to the regional context.

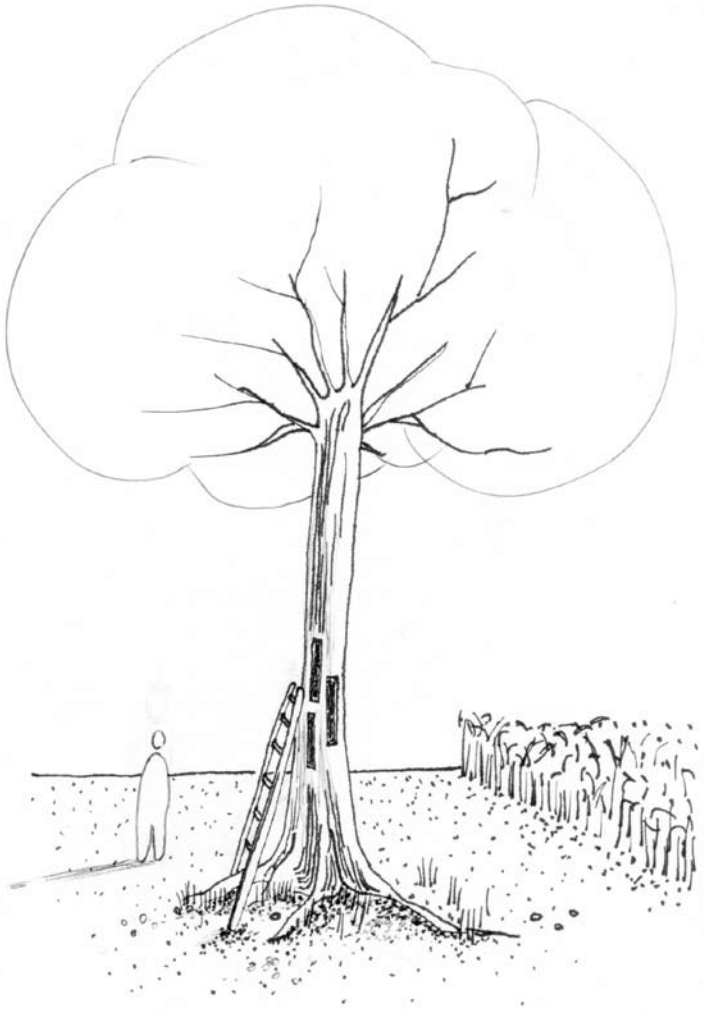
b) Conservation of existing trees and their regeneration is to be encouraged, based on the species that the farmer wants to keep on his plot. Each farmer may have a different choice according to his/her own objectives.

c) For timber species (medium- and long-term), straight trunks and narrow canopies are usually preferred.

d) Fire must be strictly avoided around planted trees, which should be protected and have their surroundings cleared regularly. It is particularly important to protect local African (native) tree species like the *Cola*, *Irvingia* or *Allanblackia* trees since they are often threatened.

e) Pruning and harvesting practices should be done carefully without affecting too much the growth of the trees using a wood saw to prune branches to keep the trunk straight, provide forage for animals or for use in mulching:

Harvesting medicinal barks in vertical alternate strips instead of all around the trunk:



Multipurpose trees are those that are deliberately grown, kept or managed for more than one use, either production or service. The roles that trees can play in an agroforestry system are numerous and include:

- Production roles: production of wood, fruit, fodder, green manure, and/or medicines.
- Service roles: tree canopy providing shade for light-sensitive plants; tree canopy and roots controlling erosion; tree stems and roots improving water infiltration through restriction of run-off; return of nutrients from deep soil to surface by deep tree roots; fixing nitrogen from the atmosphere by legumes which enrich the soil; as living hedges indicating plot boundaries as breaks; eliminating weeds through shade effect.
- Socio-cultural roles: offerings to spirits under trees, judging cases under tree shade.

Within the large group of multipurpose trees, nitrogen-fixing trees are worth noting. These trees fix atmospheric nitrogen through symbiotic microorganisms present in root nodules. They thus increase the nitrogen in the soil through the litter that accumulates on the soil and through the decomposition of nodules and roots. This supply of nitrogen can have a beneficial effect on the crops planted in association with these trees. In addition, many of these trees are also fast growing and produce fodder.

The conservation of natural tree species is particularly essential in home gardens, cocoa plantations, live fence agroforestry systems and other agroforests. To achieve this, the ability to identify tree species at young and adult stages is needed, as well as to assist natural regeneration by clearing around young trees.

Sometimes workers in charge of field operations (weeding, clearing) do not know much about useful tree species so it is important to:

1/ Make workers conscious of the importance of protecting trees and forbid them to cut any trees, whatever the species or size

2/ Identify trees to be kept on the plot with the landowner accompanied by an elder and/or an agroforestry trainer. Selected trees should be marked with rope or paint.

3/ Remove non-selected trees.

Usually, fast-growing trees or soft woods are very useful to start establishing an agroforestry system as they grow well in sunlight. Other slow-growing trees and hard timber species can be introduced later on, under the shade.

Appendix 2 indicates some agroforestry tree species that should be used and protected in the field. One should avoid introducing trees belonging to the same botanical family as the crop and similarly, one should not cultivate crops belonging to the same family as existing trees on the plot. For example, one should avoid planting trees belonging to the *Sterculiaceae* family within cocoa plantations as the cocoa tree belongs to this family. Also, one should not grow cassava in and around rubber plantations as both belong to the *Euphorbiaceae* family.

Examples of agroforestry tree species commonly encountered and used in Ghana are shown in the following table ▸

LEGEND:

FD: Food and fruits	**F**: Fodder	**WLR**: Wasteland reclamation
SC: Soil conservation	**WB**: Windbreak	**SB**: Shelterbelt
SF: Soil fertility	**BF**: Bee forage	**MD**: Medicinal
FW: Fuelwood	**LF**: Live fence	**T**: Timber
DY: Dyes	**ST**: Shade tree	**OR**: Ornamental
GM: Green manure	**FI**: Fibre	**CT**: Construction and Craft-making

Species		Major uses and functions	Other remarks
Botanical names	English(E), Ewe (V), Twi (T), Ga (G), Hausa (H), Dagbane (D)		
Acacia nilotica	Egyptian thorn(E), Bagura(D)	F, LF, GM, SF, FW, SC	Thorny leguminous plant. It is drought tolerant
Adansonia digitata	Baobab (E), Odadee (T), Zaadzo(G), Adido (V), Tua (D)	FD, MD, BF	A priority savannah species
Alstonia boonei	Nyamedua (T) Siaketekre/ Nyamidua (V)	MD, T	Bark and leaves for medicine
Artocarpus altilis	Breadnut(E) Diiboo(T) Blofo nakatie(G) Yevuzi(V)	FD	Edible fruits very palatable and satisfying
Borassus aethiopum	African fan palm (E) Agorti (V)	FD, MD T	Savannah species. Sawn for lumber and pole
Vitellaria paradoxa	Shea(E) Nkudua(T) Nku(G) Kadainya(H) Yorkuti(V), Taanga(D)	SC, F, WB, ST, FW, FD	Savannah species
Chlorophora excelsa	Iroko (E) Odum (T/V/G)	T, CT	Threatened forest species
Cola gigantea	Wawapuo (T) Wu(V)	T, MD	Native fruit, edible fruits and leaves
Cola nitida	Bitter cola(E) Bese(T) Bisi(V) Tzere(G) Guli(D)	MD, FD, FW, DY	Nerve stimulant, highly cherished in parts Northern Ghana as component of dowry
Diospyros mespiliformis	Ebony(E), Okisibiri(T), Kikirema(G),Keke(V), Ga(D)	CT, BF	High quality wood. Used for soap making
Ficus capensis	Fig(E), Oketeamforo(T/G), Vo(V), Kankana(D)	FD, F, MD, BF	Leaves as vegetable and fodder
Khaya senegalensis	Dry zone mahogany(E), Kuntunkuri(T), Logo(V), Kuga(D)	T, MD, OR	Threatened savannah species
Moringa oleifera	Moringa(E/T/G/D), Yevuti(V), Bagaaruwar-Makka(H)	FD, MD, WLR, BF, LF	Flowers, leaves, roots and young pods used as food and medicines. It is drought resistant
Parkia biglobosa	West African locust bean(E), Dawadawa(T), Atzomi(G), Ewo(V), Doo(D)	FD, MD, WLR, BF, LF, F, SC, SF, CT, WB, ST, SB	Seeds fermented and used as condiment and bark used as medicine
Pycnanthus angolensis	African nutmeg(E), Otie(T), Oti(G)	FD, T, CT, ST, FW, MD	An important agroforestry tree, with medicinal uses
Tetrapleura tetraptera	Prekese (T)	FD, DY, MD	Pods and bark use as medicine and spice
Triplochiton scleroxylon	Obeche (E) Wawa (T/V/G)	T, CT	Irregular seeding
Xylopia aethiopica	African spice tree(E), Hwenetia (T) Kalè (V)	FD, FW, CT, MD	Spice in soups

5.0. NURSERY CONSTRUCTION AND MANAGEMENT

5.1. IMPORTANCE AND PURPOSE OF NURSERIES

A nursery is the place where young plants are raised under intensive management and later transplanted to the permanent site or field. The purpose of a tree nursery is to provide a protected site for young seedlings so that they are strong and healthy when transferred to the field. Nurseries protect seedlings from theft, and from damage by animals, people, wind, rain and too much sun. The survival and vigour of out-planted seedlings can be improved by promoting nursery techniques that encourage good root development.

: : Advantages of nurseries

- Fewer seeds are required for raising seedlings in the nursery than for sowing directly into the field;
- Enables the germination and raising of seeds and cuttings which cannot ordinarily survive in normal field conditions;
- Provides young plants a better growth medium than when seeds are sown directly in the field;
- Seedlings receive more intensive care such as protection from animals, diseases and pests, regular maintenance, watering, irrigation and application of green manure, compost or artificial fertilisers;
- Opportunity for selecting well-grown, vigorous and diseases-free seedlings for transplanting.

5.2. TYPES OF NURSERIES

There are three types of nurseries: peasant, temporary/intermediate and standard/permanent nurseries.

: : Peasant nursery

These are nurseries where peasant or subsistence farmers raise their own seedlings for planting in their backyard, compound or farm. It

is usually located near the house preferably behind the bathroom shed, along streams or riverbanks, along swamps, or by any other permanent source of water.

: : Temporary (Intermediate) nursery

These are improved types of peasant nurseries and are comparatively larger than peasant nurseries. They are used to raise seedlings very close to the planting site so as to avoid the cost and problems associated with long distance transportation of seedlings. There are no permanent structures in intermediate nurseries. The site is cleared, fenced with wire netting and provided with temporary shade using materials such as palm fronds, and could serve for one season or more.

: : Permanent nursery

These are established at centralised locations within the areas they serve, and produce large numbers of seedlings on a continuous basis for a variety of needs such as establishment of plantations, shade trees, woodlots, fodder banks, arboreta, shelterbelts, ornamental plants for landscape management, etc. They are usually large and intensively managed, and contain permanent and durable structures.

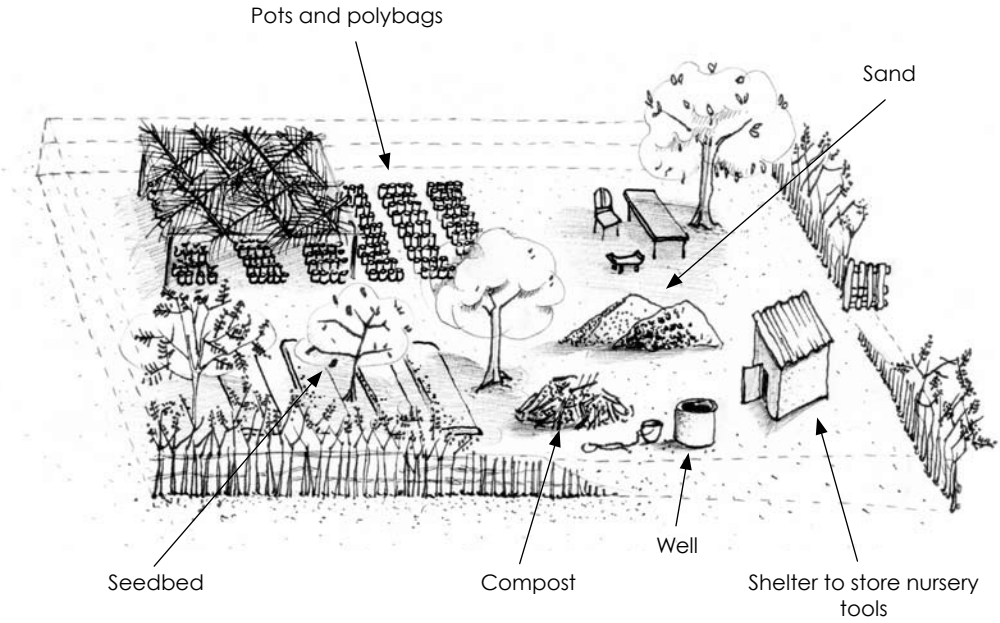
A few key management points to note on seed quality, biosafety and record-keeping are:

- Quality Seed - An adequate supply of quality seed is needed for the required species of trees. Collecting and storing good quality seed from local sources is preferable for sustainability and cost-efficiency. Seed pre-treatments that ensure uniform and rapid germination, and instructions for sowing and spacing should be adhered to.

- Bio-safety - The nursery should be clean always. Nursery tools and equipment must be cleaned after use and properly stored. Nursery worker(s) should be provided with protective materials such as gloves apron, coats, rain boots.

- Record-keeping - The nursery must be laid out to show arrangement and classes of trees available for ease of

taking records like planting dates, quantities planted, names, quantities and names of seedlings sold, price of seedlings, etc.



5.3. SELECTION OF NURSERY SITE

In choosing a site for the establishment of a nursery, a number of aspects must be considered:

- Nearness to planting site.
- Nearness to water supply.
- Nearness to good motorable road.
- Land must be fairly level with gentle slope to avoid flooding.
- Soil must be fertile with good drainage system.
- Availability of labour.
- Nearness to the market.
- Feasibility of establishing windbreaks.

Choose a site that is convenient for ease of management, protection, shade, and near a reliable water source. Avoid hilly sites, as they require considerable levelling and complicate water supply. The nursery site should be easy to reach by foot. Select sites close to the planting areas in the field. Level the ground and compress loose soil by stamping on it. A slight slope will help to drain off excess surface water. Protection from prevailing winds is also desirable. A large tree in one or two corners of the nursery is useful to provide shade for worker and to protect young seedlings from extreme weather. Nurseries with prepared seedbeds for bare-root stock need well-drained, fertile soil. In nurseries that use only pots, soil or mixtures can be brought in from outside.
A sketch showing the layout of the nursery is useful especially for large nurseries. The sketch should show the size and location of germinating seedbeds, potted seedlings, compost piles, pathways, storage space, and water sources. Paths 1-3 m wide may be left around the fence perimeter.

5.4. PREPARATION AND CONSTRUCTION OF NURSERY SITE

The major operations in the preparation and construction of nursery site include the following:

- Clearing of the nursery site, stumping, burning of the trash and removal of debris
- Levelling of the nursery site
- Laying out of the nursery site according to plan
- Fencing of the nursery
- Erecting of the shed (shading materials)
- Raising of nursery beds for germinating seeds before potting
- Potting of fertile soil into polybags (three fifths of good quality topsoil, one fifth of compost and one fifth of sand)
- Planting the windbreaks.

Notes about nursery bed:

- Levelling and terracing: After determining the size of the nursery, the first task is to terrace the slope if it is more than 10 degrees. Make terraces at least 5 m wide to allow space for two or more beds, including access paths. After levelling the site, remove all large stones and compress the soil prior to constructing the nursery beds.

- Nursery beds and land area: Nursery size depends on scale of operation. In general, a bed area of 5 m^2 is needed for 1000 seedlings regardless of whether seedlings are raised in pots or as bare-rooted stock; double this area to allow space for walkways, sheds and poles. Make individual beds 80 -100 cm wide to allow easy access to all seedlings. Make walkways between beds at least 60 cm wide. Thus, for 5,000 seedlings, the area needed is 10 m^2 x 5 = 50 m^2. Increase this to 20 m^2 x 5 = 100 m^2 if large pots are used, or if bare-rooted plants are widely spaced in seedbeds. Arrange beds in block s of 500 or 1000 to make stock taking easy. Do this by making beds 10 or 20 pots wide by 50 or 100 pots long. If possible, orient the long dimension of the beds east- west to give seedlings more uniform exposure to the sun by reducing edge effects. *See also section 5.1.*

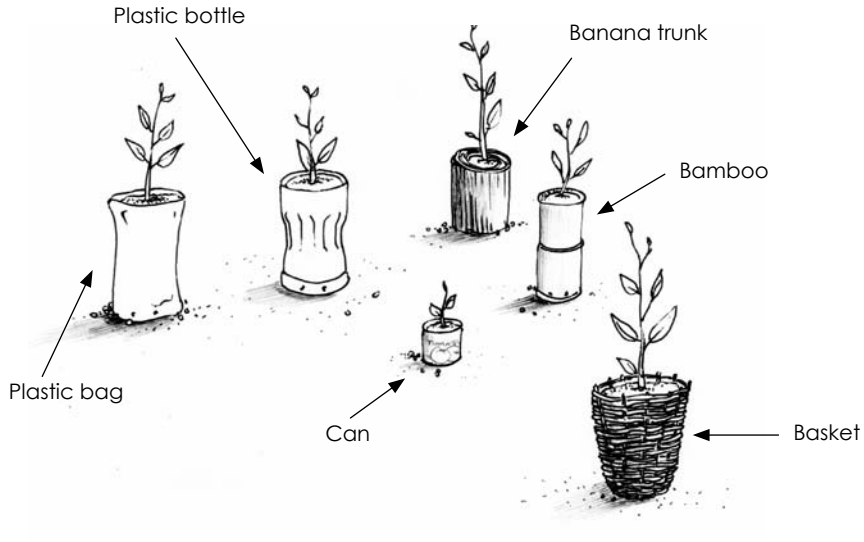
5.5. NURSERY TOOLS AND MATERIALS

Tools and materials that may be required for various operations include: cutlasses, hoes, axes, rakes, spades and shovels, secateurs, watering cans, hand forks, hand trowels, measuring tape, planting ropes, wheelbarrows, budding knives, budding tapes, labels, markers, pruning shears, pegs, polybags, topsoil, manure sieves, poles, head pans, measuring rods, seed boxes, sawdust, ash compost, fungicides, insecticides, hormones, herbicides (preferably organic).

Cutlasses, hoes and watering cans are the main tools needed. These tools are used to prepare the nursery site and seedlings,

to extract seedlings and their root mass from seedbeds, to prune roots, and to water the seedlings. Watering cans are convenient, but buckets or large tin cans with holes in the bottom will work.

Wooden boxes, plastic washbasins and other containers at least 15-20 cm deep may also be used as seedbeds. Containers should be free draining. Shallow containers (less than 15 cm) should be used only to grow seedlings for transplanting to individual containers. They should not be used to raise seedlings to planting-out size because root development is likely to be inadequate. This will result in poor survival and growth in the field.



5.6. NURSERY CULTURAL PRACTICES

: : Watering

At the germination bed and other nursery stages, the young seedlings require a lot of water. Watering should normally be carried out when the sun is not too hot, early in the morning (6-8 am) and late in the afternoon (4-7 pm). Over-watering should be avoided to prevent incidence of "damping off" diseases. Watering should be reduced during hardening stage.

: : Shading

Shading is essential particularly in the semi-arid and arid areas to prevent excessive heat to the succulent and tender plants, which lead to scorching. However, where climatic conditions are not too severe, shading may not be necessary. Heavy shading should be discouraged. The shed should be tall enough (2-3 metres) to allow enough light under it for photosynthesis.

: : Fertiliser application

Organic manure or fertiliser application should be carried out as necessary when nutrient deficiency is noticed especially yellowing of the leaves. It is advisable to add compost to the soil before potting seeds/seedlings.

: : Weeding

Weeds compete with seedlings for water, light, nutrients and also harbour pests and diseases. Weeds are a threat to the healthy development of seedlings and must therefore be controlled.

: : Root pruning

This should be done as soon as the roots grow out of the pots and penetrate through the rubber into the soil. Immediately the roots are cut the seedlings should be watered and if possible shaded for about two days. Pruning can be repeated every 3-4 weeks. Regular root pruning of side and tap roots encourages dense, sturdy root systems for most species. Shorter roots reduce damage when uplifting or moving seedlings, which make field out-planting easier with better seedling establishment.

: : Hardening off

Seedlings should be prepared gradually for field conditions one month before transplanting. Watering frequency and intensity as well as shade should be reduced so as to prepare the nursery stock for field conditions.

: : Plant protection

Some seedlings are prone to pests and disease attack. Spraying an appropriate biopesticide should therefore protect them.

: : Culling

This is the removal of dead and dying seedlings in the nursery such that only the healthy ones are taken to the field for planting. This is also to avoid the spread of diseases within the nursery. Abnormally giant seedlings may also be removed during culling to ensure that seedlings of uniform growth are planted out.

5.7. COMPARISON OF POTTED AND BARE-ROOTED STOCK SEEDLINGS

Seedlings may be grown without containers in some instances. Bare-root seedlings involve sowing seed directly into a specially prepared seedbed, from which seedlings are extracted for out-planting in the field. Use of bare-root stock simplifies nursery operations by eliminating the costs and labour involved with containers. They are especially convenient where distances between the nursery and planting sites are short. Nursery containers facilitate transporting seedlings over long distances. Containers also minimise the risk of drying out and disturbance to the roots. For this reason, containers are recommended in areas with dry climates and long travelling distances.

: : Advantages of bare root seedlings

- Easier to transport due to lower weight;
- Transplanting takes less time;
- Less care required in the nursery;
- Container costs are absent;
- Seedlings are usually large and require less protection after out-planting.

: : Disadvantages of bare root seedlings

- Seedlings need more space and more time in the nursery;
- Nursery conditions and soil must be of good quality;
- Risk of damages to plant is higher since the roots are exposed to air after extraction from the seedbed for out-planting.

: : Advantages of potted seedlings

- Seedlings can be spaced closer to save space, while time in the nursery is usually shorter;
- Pots can be moved to the planting site well before out-planting if watering can be continued;
- Root growth is contained in a package that is easier to transport, minimising exposure or drying out;
- Potted plants may survive better, and root diseases are less common.

: : Disadvantages of potted plants

- Pots are expensive and managing them is labour demanding.
- Pots are more difficult to transport because of size and weight.
- Seedlings often require frequent root pruning, which is labour intensive with risks of root damage.
- Seedlings are usually smaller when planted out, requiring more care and protection until well established.

A typical nursery setting

6.0. PROPAGATION OF AGROFORESTRY TREES

6.1. PROPAGATION FROM SEEDS

: : Collecting the seeds

Selecting the "mother tree"

The quality of seeds used for germination is a very important parameter. The tree selected to collect the seeds, or "mother tree", should have the following characteristics:

- A trunk that is as straight as possible, for timber trees;
- The tree should be in its adult stage, neither too young nor too old;
- The canopy of the tree should be well-developed, without diseases;
- For fruit tree species, fruits should be plenty, with consumer's preferred size, taste and colour.

Harvesting the seeds

Seeds should be harvested when fruits are mature, and before they open in the case of dehiscent species (fruits that open to release seeds). There are several simple techniques to harvest fruits:

Harvesting in the trees

The area under the mother trees should be cleared

- Climb the tree to collect the fruits;
- For small spiny species, shake the trunk or use a pole;
- Shake the tree for the fruits to fall.

Harvesting on the ground

The area under the mother trees should be cleared

- Pick only newly fallen fruits;
- Do not collect fruits affected by diseases, in bad state or damaged by insects.

: : Carrying the fruits

Hessian sacks or baskets should be used to carry the fruits, avoiding moisture and fungal diseases.

: : Extracting the seeds

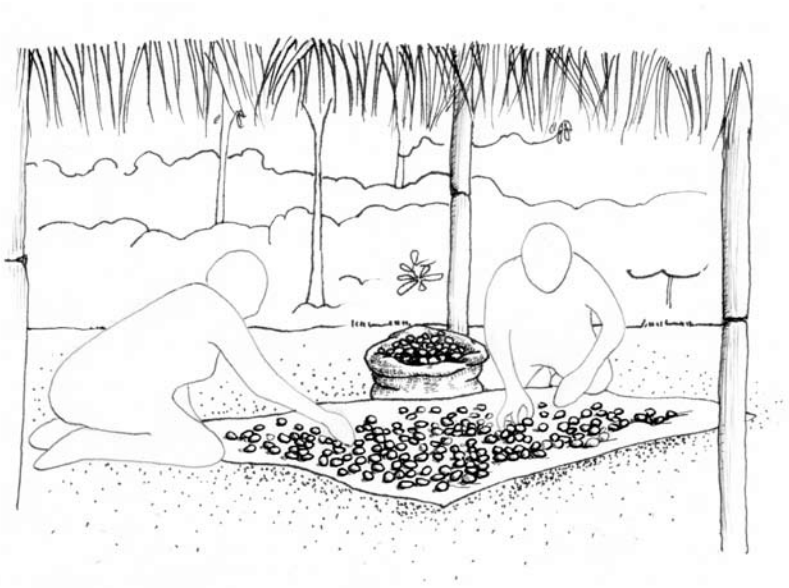
This operation consists in removing the seeds from the fruit. It should be conducted very carefully to avoid damaging the seed. There are many different methods for extracting seeds; it varies according to the type of fruits:

- Exposing fruits to sunlight so that they will open quicker (for dehiscent fruits);
- Removing the husk by hand;
- Mechanical extraction for dried fruit with hard shell.

: : Cleaning the seeds

This is to eliminate pod and capsule residues, pulp, and immature or damaged seeds. It is suggested to:

- Soak the seeds in water and eliminate those that float;
- Winnow the seeds;
- Manually separate seeds.



: : Storing the seeds

Seeds should be stored in a different bag than the one used for transportation, unless this bag has been washed. Seeds should be quickly stored after harvest, in a cool and dry place, that is protected from rodents, insects and other predators.

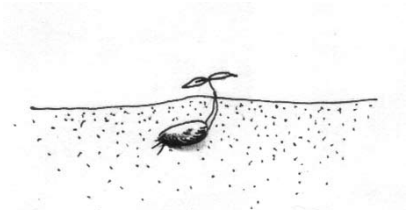
Treatments to enhance germination

- Some seeds have high water content and so must be planted without delay. Other seeds have difficulties germinating due to recalcitrance or dormancy. Specific pre-treatment methods are available to increase the rate of seed germination:

- Soaking seeds in cold water (up to a few days) or hot water (80°C maximum - up to a few hours) poured on the seeds. This is the case for *Tetrapleura tetraptera*, *Acacia auriculiformis* or *Enterolobium cyclocarpum*.
- Mechanical scarification (cutting the seed). Using a sharp blade - do not cut the area where the root will come out. One can also scratch the seed coat with sandpaper, pound the seeds in sand and/or shake the seeds in a metal box perforated to have spikes on the inside.
- Ingestion treatment by animals (ruminants, birds, etc.); excreted seeds have undergone some form of scarification.

: : Sowing the seeds

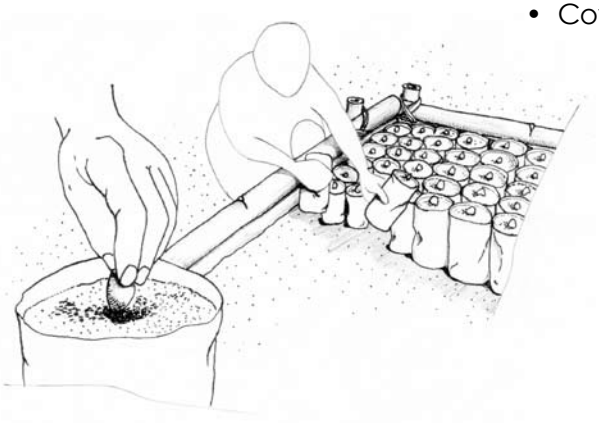
Usually, a seed is sown at a depth that is twice its own thickness, and covered with soil the same depth as its own thickness.



For leguminous tree species that present difficulties in germinating or growing, it is recommended to germinate the seeds in soil that has been removed from under the mother tree.

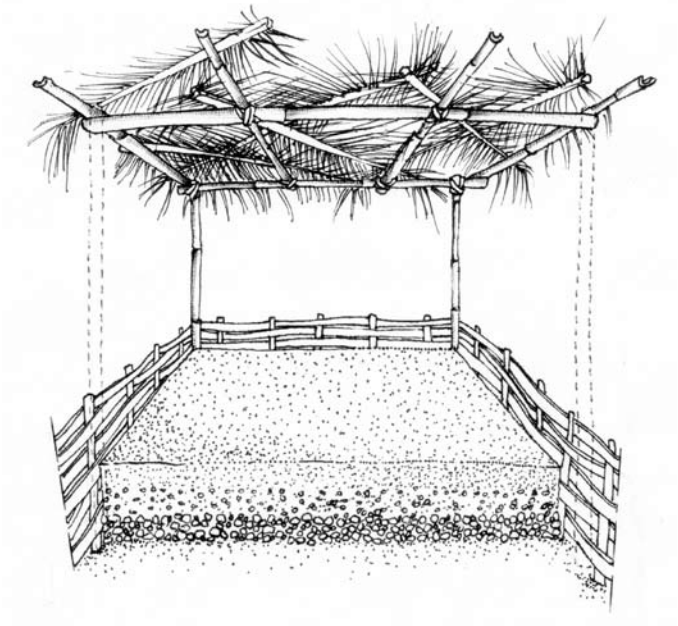
Sowing directly in pots

- Water the pots one day before sowing;
- Make small holes in the pot, for each seed to be sown;
- Sow 2 to 4 seeds in each pot, according to the germination rate. The lower the germination rate, the more seeds should be planted;
- Cover the seeds with good quality topsoil and pack smoothly;
- Water the pots very well.

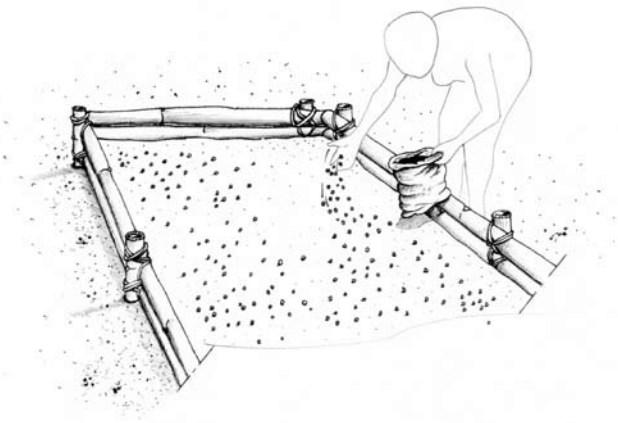


: : Seedbed

The seedbed can be surrounded by wood (bamboo for example), raised at 15 to 20 cm height and well levelled to avoid water erosion caused by heavy rainfalls. Three layers, each about 5 cm thick, can be prepared as follows:



- Bottom - a drainage layer made of rocks and gravel
- Middle - a water retention layer made of soil and topsoil
- Top - a rooting layer made of soft and fertile soil that can be mixed with sand.



Then the seeds will be sown as follows:

- Water the seedbed one day before
- Make regular small drills or furrows
- Sow small heaps of seeds in the drills at regular intervals: 10 cm space between the heaps and 20 cm space between the drills
- Gently cover the seeds with light topsoil, using a plank to smoothly pack the soil surface
- Carefully check the depth the seeds will be sown and the position of the seeds
- Water very well after sowing.

6.2. VEGETATIVE PROPAGATION (WITHOUT SEEDS)

Multiplying trees by vegetative propagation is very appropriate for species that do not provide seeds regularly or that have seeds that are difficult to germinate. Vegetative propagation also known as asexual propagation is reproduction from vegetative parts of plants. This is possible because the vegetative parts of many plants have the capacity for growth when appropriately treated, for example stem cuttings, root cuttings, leaf or single node cuttings. Vegetative propagation results in the production of genetically uniform material or "true to type" individuals, derived from a selected mother tree (the parent plant) and propagated exclusively by vegetative means.

: : Major advantages of vegetative propagation

- Accelerated plant growth and shortened fruiting period. Fruits may appear 3 to 5 years after planting instead of 10 to 12 years in the case of some native (indigenous) fruit species like *Irvingia gabonensis* (Bush mango, Abesebuo in Twi and Nzema languages).
- Preservation of genetic characteristics: flavour, colour or size of the fruits, height of the tree at adult stage, straightness of the trunk (for timber trees), etc.
- Control of mature plant size to establish plantations that are more uniform than those established using seedling plants
- An efficient way to domesticate local fruit trees and to save endangered tree species

: : Major disadvantages of vegetative propagation

- This method is more costly and time consuming than propagation through seeds.
- Some plants have more difficulties in rooting.
- As there is no real pivot within the root system, the tree might be less firmly rooted into the soil and therefore more sensitive to strong wind.
- If not carefully controlled, virus and bacterial diseases could be spread through vegetative propagation.

To succeed in propagating by using vegetative means, one should wisely select the mother tree and the time when the germplasm (vegetal material) is collected (mother tree should not be flowering or fruiting). Germplasm should be collected and transported very carefully. Techniques of layering and cuttings that are particularly relevant to domesticate native fruit trees (local, wild or indigenous species) are presented hereafter. The processes of grafting and budding, which involve uniting two parts from different plants so that they grow as one, will not be described. Grafting and budding are commonly used for improving varieties of common commercial trees such as citrus, mangoes, rubber, cocoa, etc.

Why is it necessary to domesticate native fruit trees?

Since ancient times, perennial tree species all around the humid tropics have been able to satisfy most of the needs of local communities[1] . Domestication is the process of genetically adapting an animal or plant to better suit the needs of human beings.

Whilst scientific research focuses on commercial fruit trees with an important international market (oil palm, cocoa, citrus, mango, etc.), few efforts are put on improving varieties of many African native fruit trees. And yet these local or indigenous species are of economic and social importance in many African rural areas. At the same time, farmers are not used to planting native species for

[1] Leakey, 1998; Okafor and Lamb, 1994; Abbiw, 1990

the following reasons: they grow naturally in the wild; native fruit trees take too long to fruit; and a lack of development projects that consider native fruits (training, extension work, trading, etc.).
Today, some of these African native species are threatened because of land clearance for agricultural needs, rapid urbanisation and uncontrolled harvesting of fruits. To preserve this genetic resource, it is crucial to domesticate the remaining best specimens of wild fruit trees. Prices of local fruits are rising as the resource is disappearing and trade in such fruits can represent an important source of income for the farmers.

It is imperative that farmers massively propagate and plant the best specimens of local fruit trees. In cultural terms, traditional knowledge related to the processing of such fruits (oil-making for example) is disappearing at the same time as the elders, usually women.

Promoting and introducing native fruit trees in agroforestry systems and on-farm should be encouraged on a large-scale. It is the same for timber species with high environmental and cultural values.

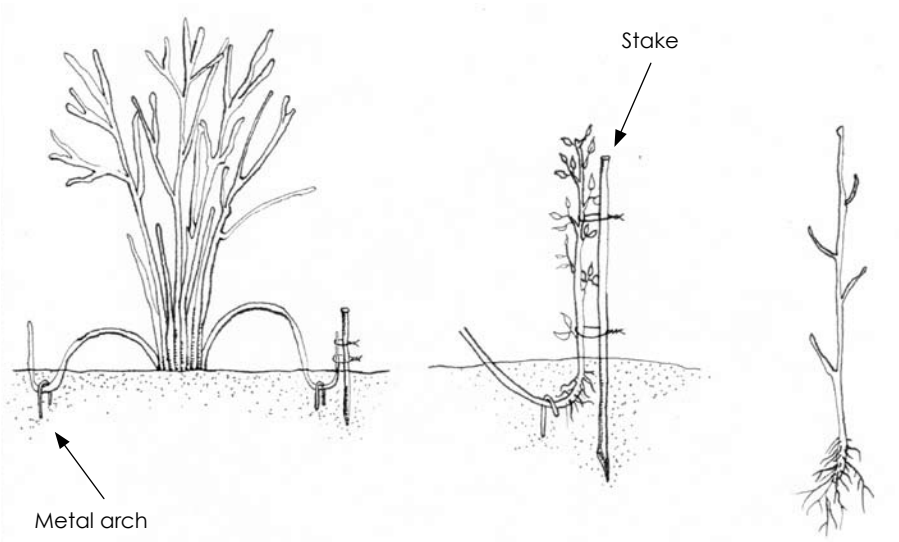
: : Layering

Existing shoots or branches of the tree are induced to form roots by covering part of the stem with soil (normal layering). When done with a moist rooting medium such as sawdust, coconut husk, etc., it is referred to as air layering. Layering is a simple process and its major advantage is the high degree of success with which some plants root when layered as compared with results achieved with other methods.

Simple and trench layering

A branch from the parent plant is bent to the ground and pegged where it is partially covered at one point with topsoil. The terminal end remains exposed. The "marcott"[2] is separated from the mother plant once roots are well developed, and placed in the nursery, Non-Mist Propagator, Humid Chamber or Propagation Box.
In the process of trench layering, the mother plant is bent to the ground and buried in a trench. As shoots arise from the buried buds, roots develop on the covered portion of the plant. The shoots may then be separated from the mother plant.

[2] Part of the branch where roots have appeared

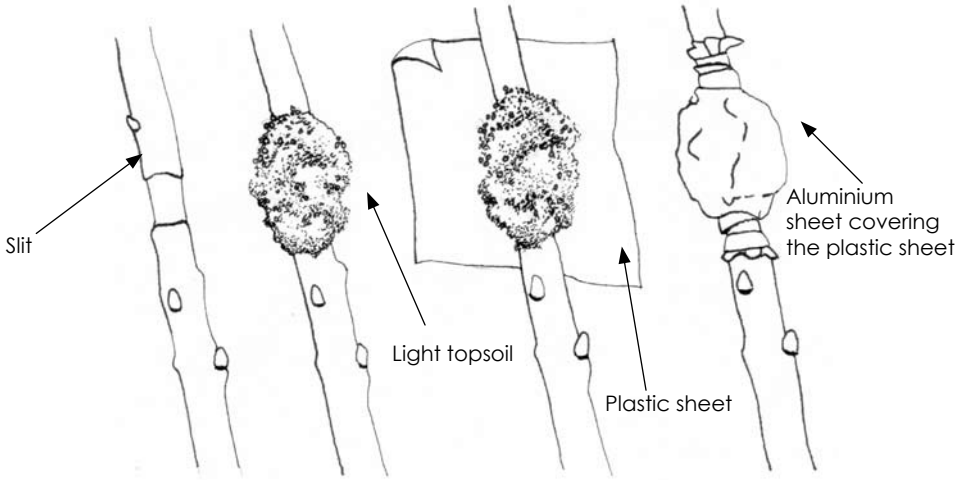


Compound layering

This is very similar to simple layering except that a stem is covered by soil at two or more points along its length.

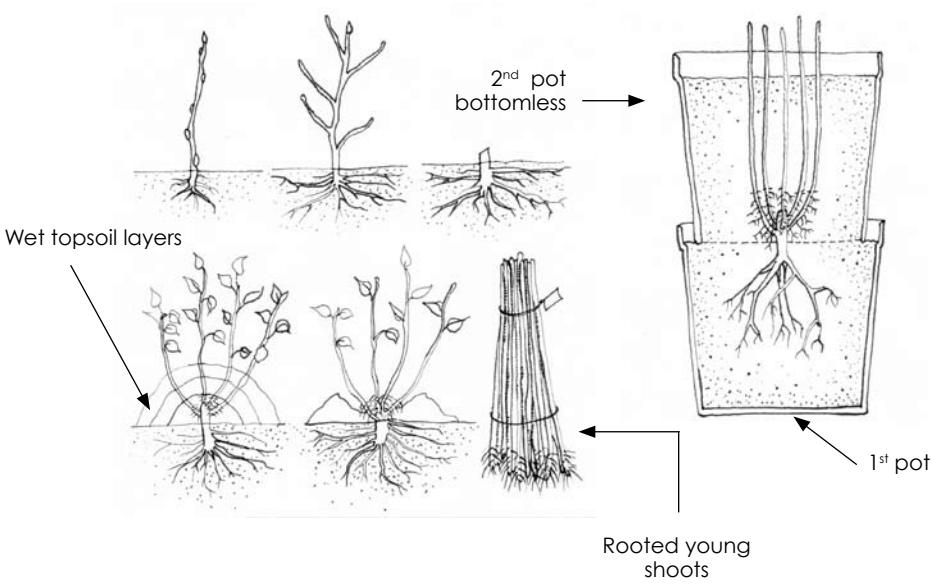
Air layering or marcotting

This technique avoids burying part of the parent plant in the soil. Instead, part of the plant stem is slit, and girdled with bark between 1.3 – 2.5 cm wide and then surrounded by a moist growing medium in some form of enclosure. Roots will develop where the plant has been wounded.



Stool layering

Stool layering begins with the planting of a rooted layer in the soil. After one season's growth, the parent plant is cut back to soil level. The stem is then covered with a mound of topsoil. Topsoil is added to the mound periodically as the shoots grow. Later, at the end of the season, the new shoots are rooted but dormant. The shoots are then cut free and planted. This type of layering can also be conducted by using two pots.

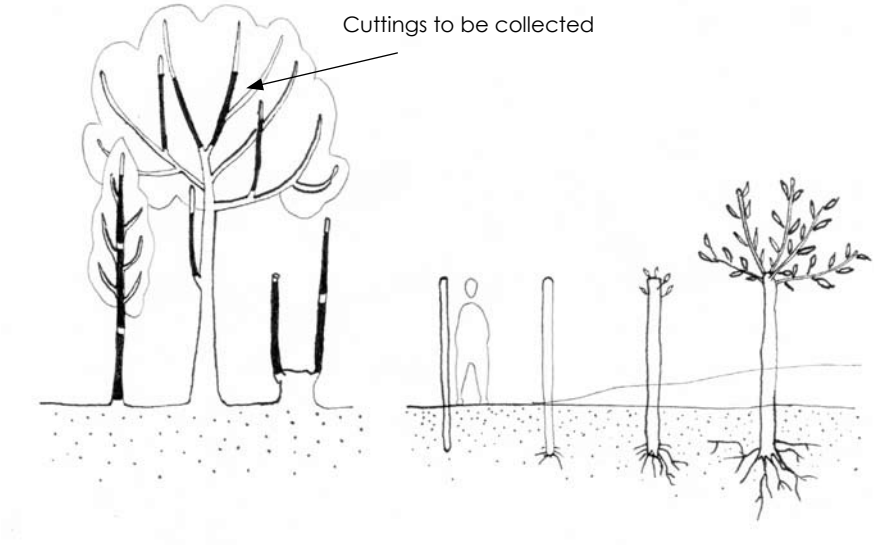


: : Propagation by cuttings

This method is well known to propagate ornamental plants but less so for agroforestry species, on-station (scientific research station) as well as on-farm (with farmers). This is particularly essential for wild fruit and timber tree species.

Working with "big" cuttings or macro cuttings (20 cm to 2 metres in length) is advantageous in that, once planted, the cutting is already a young tree that is high enough to compete with weeds. To collect macro cuttings, it is advised:

- To select branches or shoots that are at least one year-old and removing all the leaves to avoid transpiration and drying up;
- To use disinfected and sharp tools. Cuttings will be cut obliquely so that water will not stagnate on the parent plant;
- To transport and store as little as possible. The smaller a cutting, the quicker it should be planted. If stored, cuttings should be covered with a moist material (wet jute or soil, grass, etc.) and kept in a cool and dark place.
- To remove some bark at the base of the cutting and cut it again obliquely before planting it in a wet and light soil.



The propagation of trees by using small cuttings (20 cm maximum, 1 or 2 nodes) is a very efficient way to massively propagate useful species that are selected by taking into account farmers' objectives.

Removing cuttings from the parent plants is like removing them from their natural water and food supply and may eventually lead to death of the cuttings through transpiration. Therefore to prevent them from transpiring and for successful rooting of leafy cuttings, it is essential to establish a device that eliminates water stress. This can be achieved by maintaining a relatively high humidity of the air surrounding the cuttings. One of device to facilitate this is called the Non-Mist Propagator (NMP), another is called the Propagation Box (PB). Once rooted, cuttings should be potted and placed in a nursery or in a humid chamber, under the shade. The humid chamber is a simple cube covered by the transparent polyethylene sheet. In dry areas, potted cuttings have to be placed in the humid chamber to avoid excessive mortality.

The NMP is a wooden frame enclosed in a single sheet of transparent polyethylene such that the base is completely watertight. The PB is a single compartment box (about 1 m3 volume) that has the same role and function as the NMP but it is PVC made and glue is used to fix the polyethylene sheet onto the PVC pipes. The NMP construction can also be adapted by using PVC or metal pipes.

A thin layer of river sand is used to cover the base of the polyethylene of the propagator to protect the polyethylene from damage. Onto this thin layer of sand are placed large stones to a depth of 10-15 cm. This is then covered by successive layers of small stones and gravel to a total depth of 20-25 cm. The spaces between the stones and gravel are filled up with water, resulting in a permanently humid environment throughout the propagation device. The rooting medium is preferably sand that covers saturated layers of stones and gravel. Degraded sawdust (without oily residues) could also be used as a rooting medium as well as a mixture of sand and degraded sawdust. The rooting medium remains moist by capillary action and can be dampened from the above as necessary. A section of bamboo or PVC pipe is inserted in the medium and stones, which serves as a means for topping up the water and allows the water table to be monitored and maintained. The whole wooden frame is airtight with a single piece of clear polyethylene and closely fitting foam lid.

: : Conditions necessary for optimum rooting

- NMP & PB should be set under medium to dense shade and placed high enough to allow light under the different compartments of the propagator;
- Light quantity and quality should be adequate for successful rooting;
- The temperature in the NMP & the PB should be between 28-30 °C;
- High humidity should be maintained in the NMP & PB, i.e. the cuttings and the air space within the propagator should be sprayed once a day with a hand sprayer. Use a sprayer that has never been used for pesticides before;
- Never spray herbicides inside the NMP or the PB.

: : Material needed for the construction and installation of a NMP

a/ A convenient dimension of 1 m x 3 m x 1 m height, with a sloping cover should be constructed. The NMP wooden frame should also be made of durable, termite-resistant wood. Alternatively the wood should be treated with a preservative that will not affect the cuttings;

b/ Strong, high quality transparent polyethylene sheeting 2 m wide and 10 m long;

c/ Approximately 8 m of 250 x 25 mm, 10 m of 50 x 50 mm and 32 m of 50 x 25 mm timber;

d/ 0.5 m3 of broken cement blocks or stones (30-120 mm), 0.25 m3 of gravel (5-10 mm), 0.25 m3 of coarse sand;

e/ Fixing material e.g. nails of different sizes, office stapler, and drawing pin to join and fix polyethylene sheeting, hinges and screws, clips to secure covers against winds and storms;

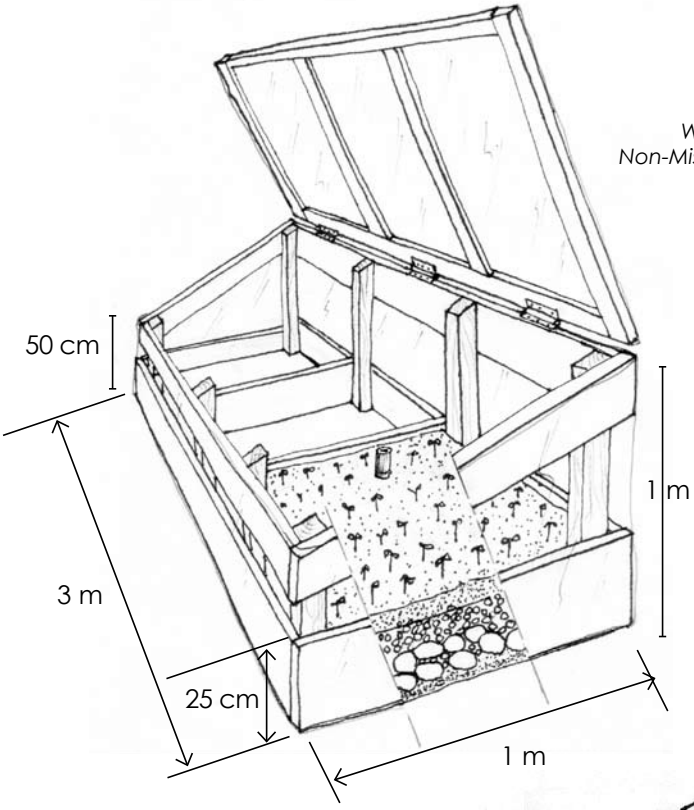
f/ A double piece of polyethylene sheet without holes is ideal for the base of the propagator. This should be left loose enough so that when it rests on the ground, it will hold the fillings without excessive pressure on the polyethylene;

g/ Under a shade "house" made of bamboo and palm leaves or shaded net or roofing sheets for example, the long axis of the NMP should be aligned East / West to ensure an homogenous sunlight on the cuttings. The ground must be carefully levelled before installing the NMP and sand must be spread on the ground where the NMP will be placed, to protect the polyethylene sheet from getting pierced. One compartment must not have more water than the other;

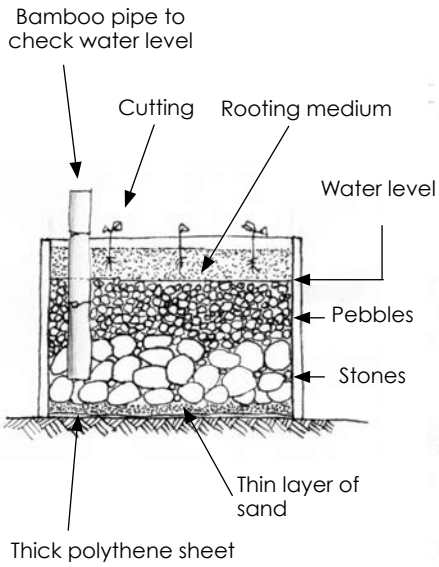
h/ Install a short piece of plastic pipe or bamboo vertically (25-30 cm long and about 5 cm in diameter) in the corner of each compartment to gauge and top-up the water level, without soaking the rooting medium;

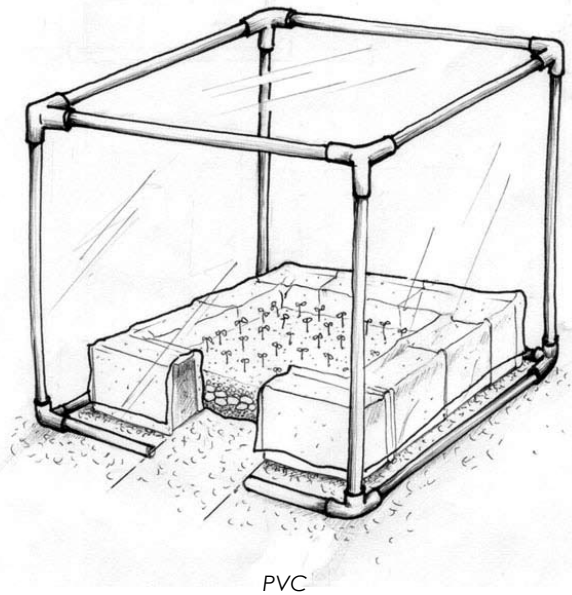
i/ All the filling/drainage materials should be thoroughly washed before use. It is also important when attaching polyethylene sheeting, to make double overlapping joints between one sheet and another, as this will help to conserve high humidity within the propagator;

j/ Add the different substrates carefully so as not to damage the polyethylene sheet: a thin layer of river sand, a thick layer



Wooden
Non-Mist Propagator





PVC
Propagation Box

of stones, a thick layer of gravel, a thin layer of sand (up to 15-25 cm), then add water through the pipe until the filling/ drainage layer is fully saturated;

k/ Add about 10 cm depth of rooting medium on the top. The rooting medium should be moist but not waterlogged, or the cuttings will not thrive.

Maintenance involves regularly checking the water level (each week); water will be added when needed using a plastic pipe. If there is too much water, the NMP can be opened for water to evaporate. The outside of the propagator should be cleaned regularly in order to allow adequate light to enter the propagator. It is important to patch up any holes in the polyethylene sheet with a small piece of sticky tape in order to conserve high humidity within the propagator.

: : Collecting and setting cuttings

a/ Trim the leaves of the selected shoots before cutting them off the stock plant; discard the terminal buds and leaves if they are considered too soft.

b/ Place the shoots quickly into polyethylene bags containing a label, marked with the species name and clone number; and moist paper or other damp material. Note which part is the top and which is the base of the cutting. In the absence of damp material, humidify the inside of the bag using a sprayer. Keep the bag closed at all times.

c/ To avoid over-heating the cuttings during transport, store them in a cool box but avoid direct contact with the cooling element.

d/ In the nursery, put the shoots into a bucket of water or spray them frequently until they are needed for use.

e/ Using a very sharp knife or secateurs cut single or double node cuttings. Cut the basal end of the cuttings squarely. Avoid cutting the base slanted as this may result in a one-sided root system.

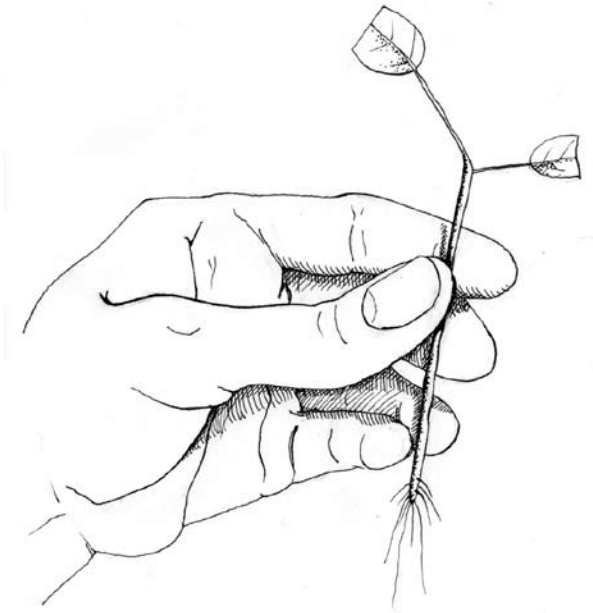
f/ Briefly dip the basal 0.5-1 cm of the cutting into the required rooting powder (0.1% to 0.8% IBA – Indole-3-Butyric Acid).

g/ Insert the cutting into a prepared hole in the rooting substrate to a depth of about 2-3 cm, making sure that the leaf is well

above the substrate, and firm the cutting in with two fingers.

h/ Label the cuttings with: species name, clone number, date of setting and treatment(s) applied. Enter the information on your assessment sheet.

i/ Spray the cuttings before closing the lid of the propagator tightly.



A rooted cutting

: : Managing the parent plants

To collect cuttings without travelling too far, it is beneficial to have the parent plants near the nursery. Lines of selected parent plants can be planted under the shade of *Calliandra spp.* or *Enterolobium spp.* for example. Space between lines can be 1 to 2 m while space between the parent plants can be 0.5 to 1 m. Special care should be given to the parent plants, adding organic manure to the soil if needed and pruning the plants about 3 times per year to stimulate the growth of new shoots. Some parent plants should be allowed to grow in order to check desired characteristics such as taste, colour and size of the fruit, fruiting period, etc.


ODUM
ABAKO

7.0. ESTABLISHMENT AND MAINTENANCE OF AN AGROFORESTRY PLOT

7.1. PLANTING AN AGROFORESTRY PLOT

The field should be cleared manually, according to the agroforestry system that has been chosen.

: : Pegging

This is to show the place where the holes will be dug. Such places can be pointed out with stakes or by making a small hole. Spaces between the trees depend on the species to be planted.

: : Making holes

This operation consists of digging the hole where the tree will be planted. Ideally, at an early stage of the rainy season, a hole 70 cm deep and 70 cm wide will be dug, depending on the species, one month before planting the tree. Sunlight and rain will then have time to soften the bottom of the hole.

: : Selecting and transporting young trees

Before planting, it is important to select trees by burning those that are weak or affected by diseases.

For transportation, it is important to respect the following:

- Water the young trees one day before movement.
- Transport young trees early in the morning or late in the day, avoiding the sunlight.
- Make sure you have prepared an appropriate place to receive young trees.

: : Planting the young tree

- Handle gently, ensuring you keep the clump of earth surrounding the roots;
- Cut the bottom of the pot (polybag) and place it straight in the hole;
- Fill the hole with soil without packing it too densely;
- Pull the polybag to remove it;
- Pack the soil around the young tree;
- Water the young tree.

If there is no substantial rain within two days of planting, the tree must be carefully watered.

: : Protecting the young trees

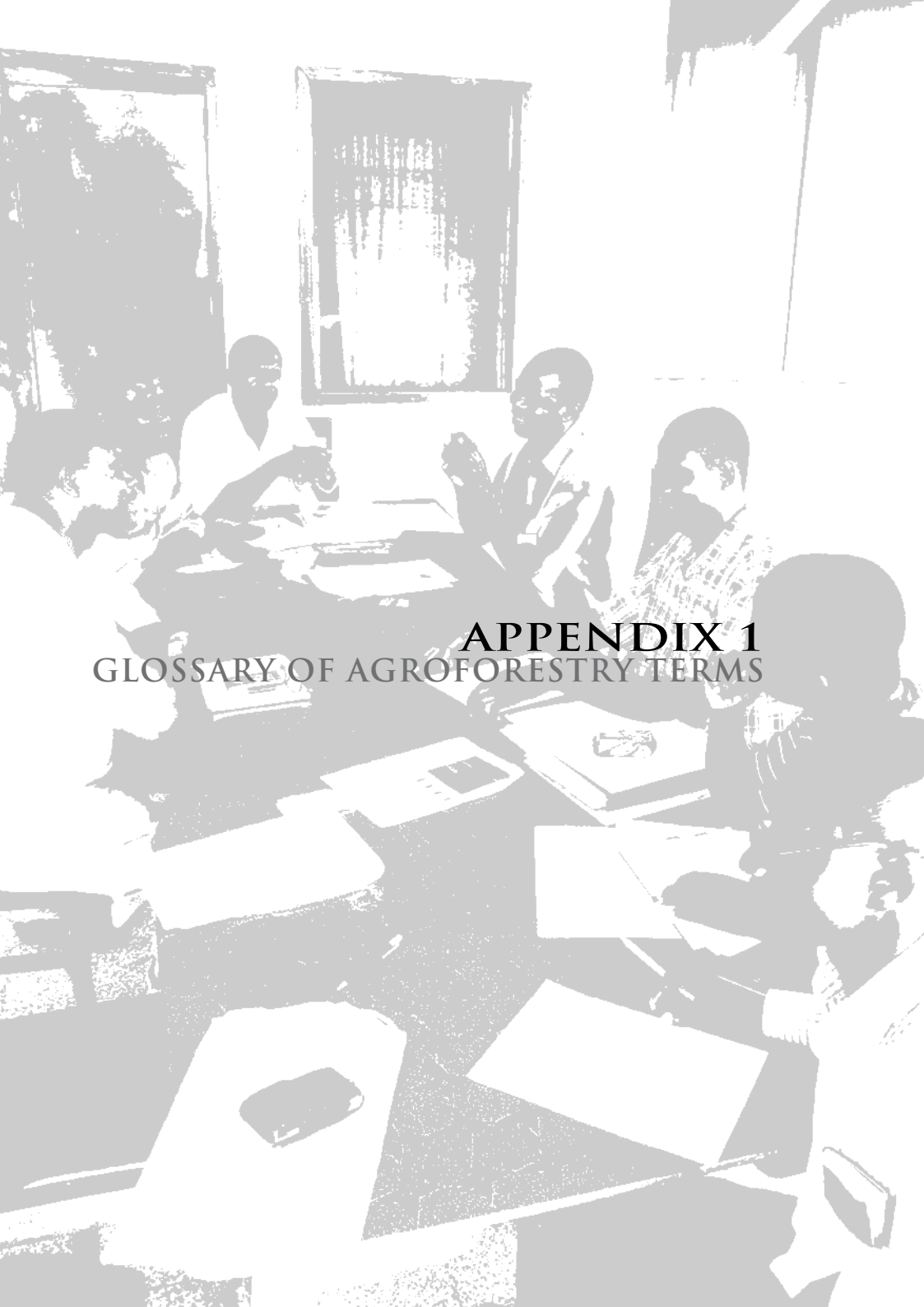
Young trees should be protected by all possible means from animals, particularly cows and goats. It is sometimes possible to combine the following practices:

- Constructing an individual protection using bamboo, palm leaves or wood
- Surrounding young tree with spiny branches
- Wrapping the trunk with textile fabric for the animals not to eat the bark
- Putting a topless and bottomless barrel on the young tree.

After planting, it is important to monitor young trees well, including protecting and caring for them (watering, weeding around, etc.). Suckers should be removed regularly. A sucker is a new growth on an existing plant that develops under the ground from the root or the main stem, or from the stem below a graft (i.e. part where a new plant has been joined on).

It is important to remove weeds around a tree at least twice yearly in the rainy season during the during its first 3 years.

Dead trees should be replaced during the next rainy season. During the dry season, it is recommended not to weed around the trees as weeds help to keep moisture.



APPENDIX 1
GLOSSARY OF AGROFORESTRY TERMS

GLOSSARY OF AGROFORESTRY TERMS

Afforestation
Conversion of bare land into forestland by planting of forest trees. Or the planting of a forest crop on land that has not previously, or recently carried a forest crop.

Agrisilviculture
A form of agroforestry consisting of trees (woody perennials) and arable crops.

Agroforestry
Growing trees (woody perennials), crops, and animals on the same land management unit

Agrosilvopastoral
A form of agroforestry consisting of trees, crops and animals/pasture.

Alley cropping (hedgerow intercropping)
Cropping between lines of trees and shrubs preferably leguminous species. Or an agroforestry intercropping system in which species of shrubs or trees are planted at relatively close spacing within rows and wide spacing between rows, to leave room for herbaceous cropping between the alleys.

Browse
The buds, shoots, leaves, pods and flowers of trees and shrubs that are eaten by livestock or wild animals.

Budding
The practice of splicing a bud from one tree into the bark of another, usually to obtain high quality or improved fruits on strong established trees.

Buffer zone
An area around a forest, national park, or any other conserved place that provides the local community with products that they

would otherwise take from the forest, or that provides an opportunity to produce alternative products.

Bush fallow
The natural vegetation that arises when land is left uncultivated for some time. Composed of small trees, shrubs, grasses, sedges and herbaceous plants. Bush fallow may be grazed or browsed and firewood collected from it before it is returned to cultivation. Related terms: enriched fallow, shifting cultivation.

Community forestry
Forestry developed in areas marginal to agriculture, with many members of the community being landless or small-scale farmers, often characterised by ecological and cultural diversity and the employment of traditional technologies. Communal land development is basic to this type of forestry. Related terms: social forestry.

Cutting
A piece of branch or root cut from a living plant with the purpose of developing roots and growing a new plant genetically identical to the original.

Domestication
To domesticate is to settle as a member of a household; cause to feel at home; naturalise (especially a plant or an animal). Domesticating agroforestry trees involves accelerated and human-induced evolution to bring species into wider cultivation through a farmer-driven or market-led process. The idea of domestication is closely linked to the idea of selection, for fitness of purpose, of pushing nature into a higher gear and in a particular direction.

Enriched fallow
A form of agroforestry in which useful, mainly woody species are sown or planted before or after cultivation ceases, so that during the fallow period, or when the land is next cleared for cultivation, products are available for household use or market that would not otherwise have been there (e.g. fruits, bamboos, medicines). Related term: fallow.

Erosion
The wearing away of the land surface by running water or wind.

Evapotranspiration
Total loss of water from a given area and during a specific period of time, by evaporation from the soil surface and by transpiration from the plant.

Exotic
A plant or animal species that has been introduced outside its natural origin. It is opposite to native or indigenous.

Fallow
Allowing cropland to lie idle, either tilled or untilled, during the whole or greater portion of a growing season. Tillage is usually practiced to control weeds and encourage the storage of moisture in the soil. Or land rested from deliberate cropping, not necessarily without cultivation or grazing but without sowing. Land left without a crop or weed growth for extended period, often to accumulate moisture. Related term: bush fallow.

Farm forestry
Growing trees for timber, poles, fuelwood on farmland. This may be done in small woodlots or as boundary plantings. Related term: tree gardens.

Fodder bank
Fodder banks plants are usually trees or shrubs, and often legumes that can be directly grazed by livestock.

Fodder
Part of plant eaten by domestic animals. May include leaves, stems, pods, flowers, pollen, or nectar.

Forest garden
A form of land use on private lands outside the village in which planted trees and sometimes additional perennial crops occur.

Germination bed
A small area of land dedicated to raising young seedlings from planted seeds.

Grafting
The practice of propagating plants by taking a small shoot from one plant and attaching it to another plant so that the internal tissues from both are in contact and the transferred shoots grows as part of the main plant. This is normally used to obtain high quality fruits from strong well-established plants or rootstock.

Green manure
Green leafy material applied to the soil to improve its fertility. Or crops that are grown for soil protection, biological nitrogen reduction, or organic matter and ploughed, disked or hoed into the soil or any crop grown for the purpose of being turned under while green, or soon after maturity, for soil improvement.

Growth hormones
Substances that initiate, inhibit or regulate roots and shoot formation in cuttings. They are of various types: IBA – Indole Butyric Acid, IAA –Indole Acetic Acid, NAA – Naphtalene Acetic Acid, GA – Gibberellins. Coconut water could be use as rooting substance.

Hedgerow
A closely planted line of shrubs or small trees, forming a boundary or a fence.

Herbaceous
A plant that is not woody.

Home-garden
A form of land use on private lands surrounding individual houses with a definite fence, in which several tree species are cultivated together with annual and perennial crops, often with the inclusion of small livestock. There are many forms of such gardens varying in how intensively they are cultivated and their location with regard to the home, for example, village forest gardens, compound gardens, and kitchen gardens.

Improved Fallow
The replacement or enhancement of natural fallow vegetation by the introduction of selected trees.

Indigenous
Native to a specific area. Not introduced. Opposite to exotic.

Intensive
Land use or management concentrated in a small area of land. Opposite to extensive.

Intercropping
The cultivation of two or more crops simultaneously on the same field, with or without a row arrangement or the growing of two or more crops on the same field with the planning of the second crop after the first one has already completed development. Also called relay cropping. Related terms: mixed cropping, multiple cropping.

Layering
Existing shoots or branches of the tree are induced to form roots by covering part of the stem with soil (normal layering).

Live fence
A way of establishing a boundary by planting a line of trees and or shrubs, at relatively close spacing and by fixing wires to them. If animals are to be kept in or out, more uprights (dead sticks) can be tied to the wires. Also called a living fence.

Monoculture
The repeated cultivation of the same sole crop on the same land.

Mulch
A natural or artificially applied layer of plant residues or other materials such as stones, sand, paper or brush on the surface of the soil. Or a covering of plant material put on the soil to improve its fertility, moisture retention capacity and organic content. Or a loose surface horizon that forms naturally or may be produced by cultivation and consists of either inorganic or organic materials.

Multi-storey cropping
The vertical arrangement of plants so that they form distinct layers, from the lower (usually herbaceous) to the upper-most tree canopy.

Nitrogen fixation
Biological conversion of elemental nitrogen from the atmosphere to organic forms that are readily absorbed for crop growth and development.

Nitrogen
An element which is a nutrient required by crops for optimum growth and development.

Palatable
Agreeable to the palate or taste.

Perennial plant
A plant that grows for more than one season in contrast to an annual that grows for only one season before dying.

Pollarding
Removing the crown of a tree in order to harvest wood and browse to produce re-growth beyond the reach of animals and/or to reduce shade cast by the crown.

Shelter
A type of windbreak that consists of long, multiple rows of trees and shrubs, to protect agricultural fields, for instance from tidal winds.

Shelterbelt
An extended windbreak of living shrubs established and maintained for the protection of farmlands over an area larger than a single farm.

Shifting cultivation
Found mainly in the tropics, especially in humid and sub-humid regions. There are different kinds e.g. where settlements are permanent, but certain fields are fallowed and cropped alternately (rotational agriculture). In others, whole settlements move and clear new land once the old is no longer productive.

Silvopastoral system
A form of agroforestry system consisting of the trees (woody perennial) and pasture/animal components. Related term: forest grazing.

Soil Organic Matter
Plant and animal residues at various stages of decomposition in the soil.

Soil productivity
Capacity of a soil for producing a specified plant or sequence of plants under a specified system of management. Productivity shows the capacity of a soil to produce plant products and should be expressed in terms of yield.

Strip cropping
Growing two or more crops simultaneously in different bands wide enough to permit independent cultivation but narrow enough for crops to interact agronomically. Related terms: zonal forestry system, or growing crops in a systematic arrangement of strips or bands to serve as vegetative barriers to wind and water erosion. Related terms: wind strip, barrier hedge, or the practice of growing crops in narrow bands along the contour in an attempt to reduce runoff, thereby preventing erosion or conserving moisture.

Sucker
A side shoot from the roots of the plant. A side growth arising from an auxiliary bud.

Taungya system
Method of raising forest trees in combination with seasonal agricultural crops. Used in the early stages of establishing a forest plantation. It not only provides some food but can also lessen the establishment costs.

Thinning
Intermediate removal of trees to control the growth of stands by adjusting plant density.

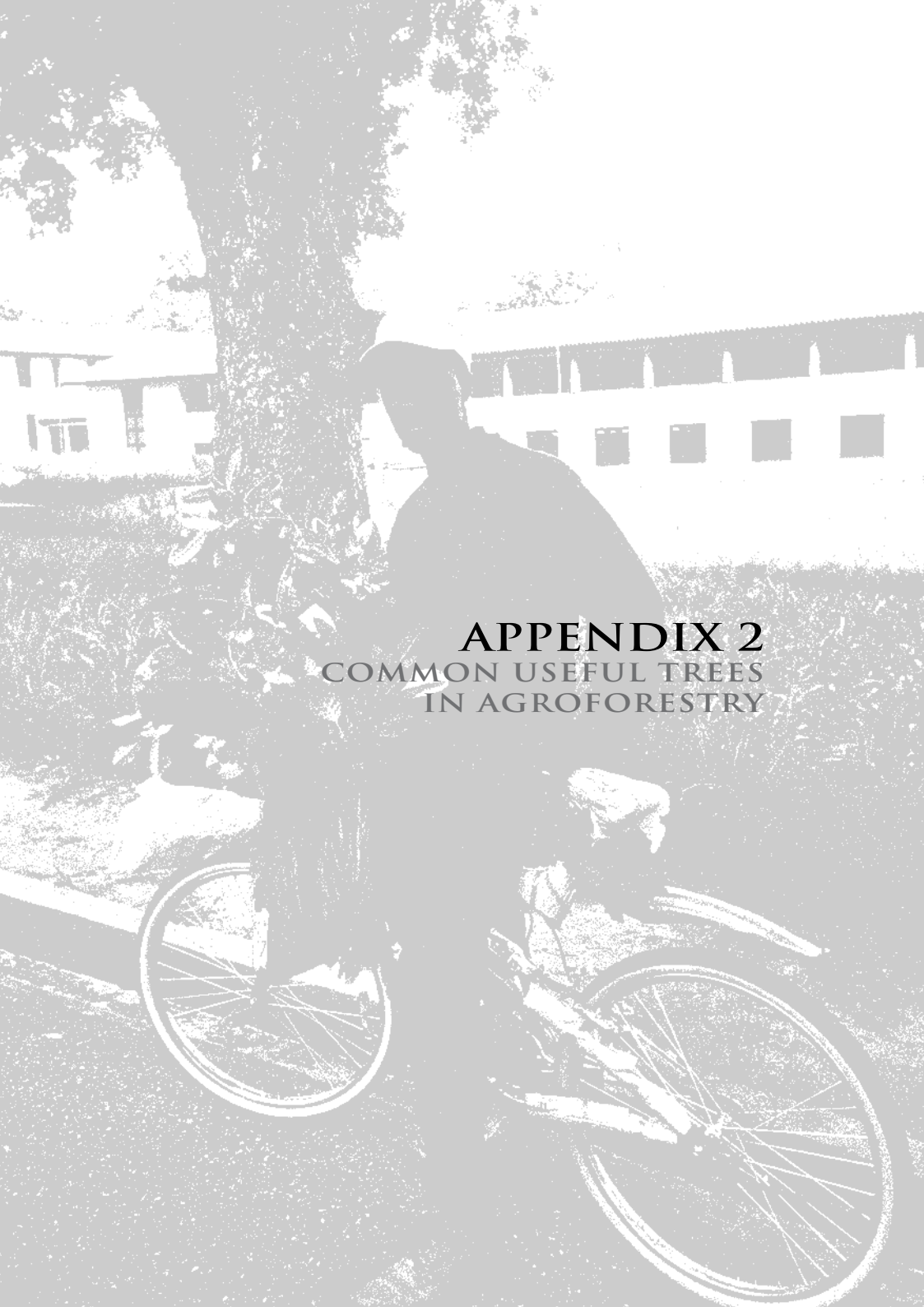
Tree farming
Any agroforestry practice that incorporates trees into farmland. Related term: farm forestry.

Tree garden
A multi-storeyed agroforestry system in which a mixture of several

fruit and other useful trees are cultivated, sometimes with the inclusion of annual crops. Related terms: home garden, mixed garden, village forest garden.

Windbreak
A group of trees or shrubs in any arrangement that will afford protection from high winds to animals or crops or both. When the arrangement is in a long line the group is called a shelterbelt. If an associated reason is also to harvest timber at some future date it is sometimes called a timber belt. Related term: wind strip.

Zero tillage
Growing crops without any significant cultivation of the soil, and often by leaving the previous crop residues on the soil surface as protective mulch. Related terms: minimum tillage, stubble mulching.



APPENDIX 2
COMMON USEFUL TREES IN AGROFORESTRY

SPECIES		MA						
BOTANICAL NAMES	ENGLISH(E) EWE(V) TWI(T) GA(G) HAUSA(H) DAGBANE(D)	FOOD AND FRUITS	SOIL CONSERVATION	SOIL FERTILITY	FUELWOOD	DYES	GREEN MANURE	CONSTRUCTION & CRAFT-MAKING
Acacia albida	Albida(E), Gawo(H), Puhu-wuni(D)		✔	✔	✔		✔	
Acacia nilotica	Egyptian thorn(E), Bagura(D)		✔	✔	✔		✔	
Adansonia digitata	Baobab(E), (A)dido(V), Odadee(T), Zaadzo(G), Tua(D)	✔						
Albizia adianthifolia	Vena(V), Pampena(T), Pampladza(G)				✔			✔
Albizia coriaria	Kulefante(V), Awiemfosamina-akoa(T)							✔
Albizia zygia	Kulo(E), Okoro(T), Ledzo(Ga)		✔	✔	✔		✔	
Alstonia boonei	Siaketekre(V), Nyamedua(T)							
Anacardium occidentale	Cashew(E), Yevu-tsa(V), Ateaa(T), Atea(G)	✔			✔	✔		
Aningeria robusta	Samfena(T), Asanfra(V)							✔
Anogeissus leiocarpus	Anogeissus(E), Kane(T), Sakane(Ga), Tsetse(V), Shia(D)	✔			✔		✔	
Artocarpus altilis	Breadnut(E), Yevuzi(V), Diiboo(T), Blofo nakatie(G)	✔				✔		
Artocarpus communis	Breadfruit(E), Diball(T)	✔				✔		
Azadirachta indica	Neem(E), Sabalati(V), Gyadua(T), Nim(D)				✔			
Baphia nitida	Camwood(E), Odwon(T), Aboloobaatso(G), Odzori(V)			✔	✔			
Blighia sapida	Akee apple(E), Adza(V), Akyee fufuo(T), Ayigbe atia(G), Kpihiga(D)	✔			✔			✔

AJOR USES AND FUNCTIONS											OTHER REMARKS
FODDER	WINDBREAKS	BEE FORAGE	LIVE FENCE	SHADE TREE	FIBRE	WASTELAND RECLAMATION	SHELTERBELT	MEDICINAL	TIMBER	ORNAMENTAL	
✔		✔	✔			✔					Coppices very well. Highly leguminous. Hedge crop.
✔			✔								Thorny leguminous drought tolerant plant.
✔		✔						✔			A priority savannah species.
				✔				✔			Common in moist savannah zone.
									✔		High forest species, desirable shade tree in cocoa.
✔		✔		✔		✔					Highly leguminous. Useful in soil improvement.
								✔	✔		Bark and leaves for medicine.
		✔						✔			Cash crop, edible fruits and drought resistant.
									✔		Wild fruit. Threatened forest species.
✔	✔			✔							Savannah species. Gum yielder.
✔									✔		Edible fruits very palatable and satisfying. Seeds can be fried or roasted. Leaves as fodder.
✔									✔		Edible fruits – usually boiled. Leaves as fodder. Dye. Bark cloth. Wood used for canoes and tinder.
		✔	✔	✔		✔		✔	✔		Highly tolerant to drought. Leaves and seeds use for natural insecticide.
	✔		✔	✔							Good for alley cropping.
								✔			Avenue planting. Edible oil. Cheap furniture. Charcoal. Bark used for medicine.

SPECIES		MA						
BOTANICAL NAMES	ENGLISH(E) EWE(V) TWI(T) GA(G) HAUSA(H) DAGBANE(D)	FOOD AND FRUITS	SOIL CONSERVATION	SOIL FERTILITY	FUELWOOD	DYES	GREEN MANURE	CONSTRUCTION & CRAFT-MAKING
Borassus aethiopum	African fan palm(E), Agorti(V)	✔						
Cajanus cajan	Pigeonpea/Redgram(E), Atiyi / Amdzimuta(V), Atii(G)		✔	✔	✔			
Carapa procera	Kwakuo bise(T)							✔
Carica papaya	Pawpaw(E), Borofere(T), Akpakpa(Ga), Adiba(V)	✔						
Carissa edulis	Akoko –besa(T, G), Aflamgme Dmeetso(Ada), Ndimangoa (Dagari)	✔			✔			
Cassia siamea	Cassia(E), Sangarati / Kasiati(V)		✔	✔	✔			✔
Cedrela mexicana	Cedrela / cedar(E)							✔
Ceiba pentandra	Silk cotton tree / Kapok(E), Vule/ Loe(V), Onyina(T), Onyaitzo(G), Rimi(H), Guna(D)	✔	✔		✔			✔
Cinnamonum zeylancium	Cinnamon(E/T)	✔						
Citrus aurantiifolia	Lime(E), Mumoe(V), Ankaatwadee (T), Abonua(G), Nyamsa(D)	✔						
Citrus aurantium	Sour orange(E), Vomumoe(V), Aborokaa(T)	✔						
Citrus limon	Lemon(E), Anuti(V), Dware ansra(T)	✔						
Citrus sinensis	Sweet orange(E), Akutu(T/G), Atotonuti(V)	✔						
Cocos nucifera	Coconut(E), Agorneti(V), Kube(T)	✔	✔					✔
Coffea spp.	Coffee(E), Kofe(T/V), Kafe(G)	✔						

AJOR USES AND FUNCTIONS											OTHER REMARKS
FODDER	WINDBREAKS	BEE FORAGE	LIVE FENCE	SHADE TREE	FIBRE	WASTELAND RECLAMATION	SHELTERBELT	MEDICINAL	TIMBER	ORNAMENTAL	
								✔	✔		Savannah species. Sawn for lumber and poles.
✔	✔		✔	✔							Shrub that thrives well in both humid and sub-humid conditions.
								✔	✔		Wild cocoa, bean oil for soap.
								✔			Cash crop. Common in home gardens.
✔			✔					✔		✔	It is a highly branched and spiny small tree, shrub or scrambler. Glabrous plant. The roots are used as spice. Fruits are sweet, and usually added to food of invalid as an appetizer.
	✔		✔	✔							Coppice after cutting.
	✔							✔	✔		Timber species.
✔	✔		✔	✔					✔		High forest species (up to 160 ft). Sacred in West Africa. Used as cotton substitute, for upholstery etc. Seeds contain edible oil.
								✔			Exotic but adapted to local forest conditions. Leaves and bark used as spice and for flavouring.
		✔									Cash fruit crop. Common in home gardens.
		✔						✔			Common in home gardens.
		✔						✔			Cash fruit crop. Common in home gardens.
		✔									Cash fruit crop. Common in home gardens.
✔		✔						✔			Commonly found in coastal areas. Nut eaten fresh of process into milk, jam, cosmetic, animal feeds etc.
		✔									Cash crop.

SPECIES		MA						
BOTANICAL NAMES	ENGLISH(E) EWE(V) TWI(T) GA(G) HAUSA(H) DAGBANE(D)	FOOD AND FRUITS	SOIL CONSERVATION	SOIL FERTILITY	FUELWOOD	DYES	GREEN MANURE	CONSTRUCTION & CRAFT-MAKING
Cola gigantea	Wu(V), Wawapuo(T)							
Cola nitida	Bitter cola(E), Bisi(V), Bese(T), Tzere(G), Guli(D)	✔			✔	✔		
Crescentia cujete	Calabash tree(E), Goti(V)				✔			✔
Diospyros mespiliformis	Ebony(E), Keke(V), Okisibiri(T), Kikirema(G), Ga(D)							✔
Elaeis guineense	Oil palm tree(E), Deti(V), Abe(T), Nme(G)	✔						
Entandophragma angolense	Edinam(T)							✔
Erythrina senegalensis	Coral flower(E), Akoble(V), Osurokasoro (T), Nyabaatso(G)			✔				
Ficus anomani	Doma(T)							
Ficus capennsis	Fig(E), Vo(V), Oketeamforo (T/G), Kankana(D)	✔						
Ficus exasperata	Sandpaper tree(E), Tataflala(V), Nyankyerene (T), Nyankese(G)		✔		✔			
Funtumia africana	False rubber tree(E), Kpomi(V), Okae/Sese(T), Ose-seo(G)							
Funtumia elastic	Wild rubber/West African rubber(E), Ofurntum (T/V)							
Garcinia kola	Twapea / Minchingoro(H) / Nsoko(T)							
Gliricidia sepium	Mother of cocoa(E), Kookoo-adamfo(T)		✔	✔	✔		✔	
Griffonia simplicifolia	Gbogbotri/Gogo(V), Kagya (T), Kanya(G)					✔		✔

AJOR USES AND FUNCTIONS											OTHER REMARKS
FODDER	WINDBREAKS	BEE FORAGE	LIVE FENCE	SHADE TREE	FIBRE	WASTELAND RECLAMATION	SHELTERBELT	MEDICINAL	TIMBER	ORNAMENTAL	
								✔	✔		Native fruit, edible fruits and leaves.
								✔			Nerve stimulant. Appetite depressant. Paste applied to lesions. Highly cherished in parts Northern Ghana as part of dowry.
											Useful for wood utensil like calabash.
		✔									High quality wood. Used for soap making.
✔	✔	✔		✔	✔						Palm oil extraction.
								✔	✔		Threatened high forest species.
✔			✔								Thrives well in both humid and sub-humid conditions.
			✔								A liana that can become a small tree.
✔		✔						✔			Leaves as vegetable and fodder leaves
			✔	✔	✔						Wild fig. Browsing and fodder for zero grazing. Leaves good for mulching
		✔						✔			Multipurpose, highly medicinal. The yellow-white flowers are visited by bees for nectar and pollen.
		✔						✔			African rubber tree. Funtumia has important antioxidant, antifungal, anti-inflammatory, and antibiotic properties.
				✔				✔			Chewing stick. Germicide for teeth. Threatened species
✔		✔	✔			✔					Coppices very well. Highly leguminous. Hedge crop.
✔								✔			Woody climber found in thickets. Sweet roots used chewed.

SPECIES		MA						
BOTANICAL NAMES	ENGLISH(E) EWE(V) TWI(T) GA(G) HAUSA(H) DAGBANE(D)	FOOD AND FRUITS	SOIL CONSERVATION	SOIL FERTILITY	FUELWOOD	DYES DYES	GREEN MANURE	CONSTRUCTION & CRAFT-MAKING
Guarea cedrata	Kwabohoro(T)							
Irvingia gabonensis	Wild mango/ Dika nut, Abesebuo (T)	✔						✔
Irvingia wombulu	Abesebuo-kese (T), Ator(V)	✔						✔
Khaya senegalensis	Dry zone mahogany(E), Logo(V), Kuntunkuri(T), Kuga(D)							
Kigelia africana	Sausage tree(E), Nufuten(T)							
Lecaniodiscus cupanioides	Dwindwera(T)							
Mangifera indica	Mango(E), Amango(T/V), Mango(G)	✔	✔	✔	✔			
Milicia (Chlorophora) excelsa	Iroko(E), Odum (T/V/G)							✔
Milletia thonningii	Atsite(V), Sante(T), Tatzo(G)			✔	✔			
Moringa oleifera	Moringa(E/T/G/D), Yevuti(V) Bagaaruwar-Makka(H)	✔						
Musa acuminata	Banana(E), Akodu(V), Kwedu(T)	✔						
Myrianthus arboreus	Avaglo(V), Anyankoma(T)	✔						
Nauclea diderrichii	Opepe(V), Abako(T)							
Newbouldia laevis	Sasanemasa (T), Hiatzo(G), Avia(V)				✔			

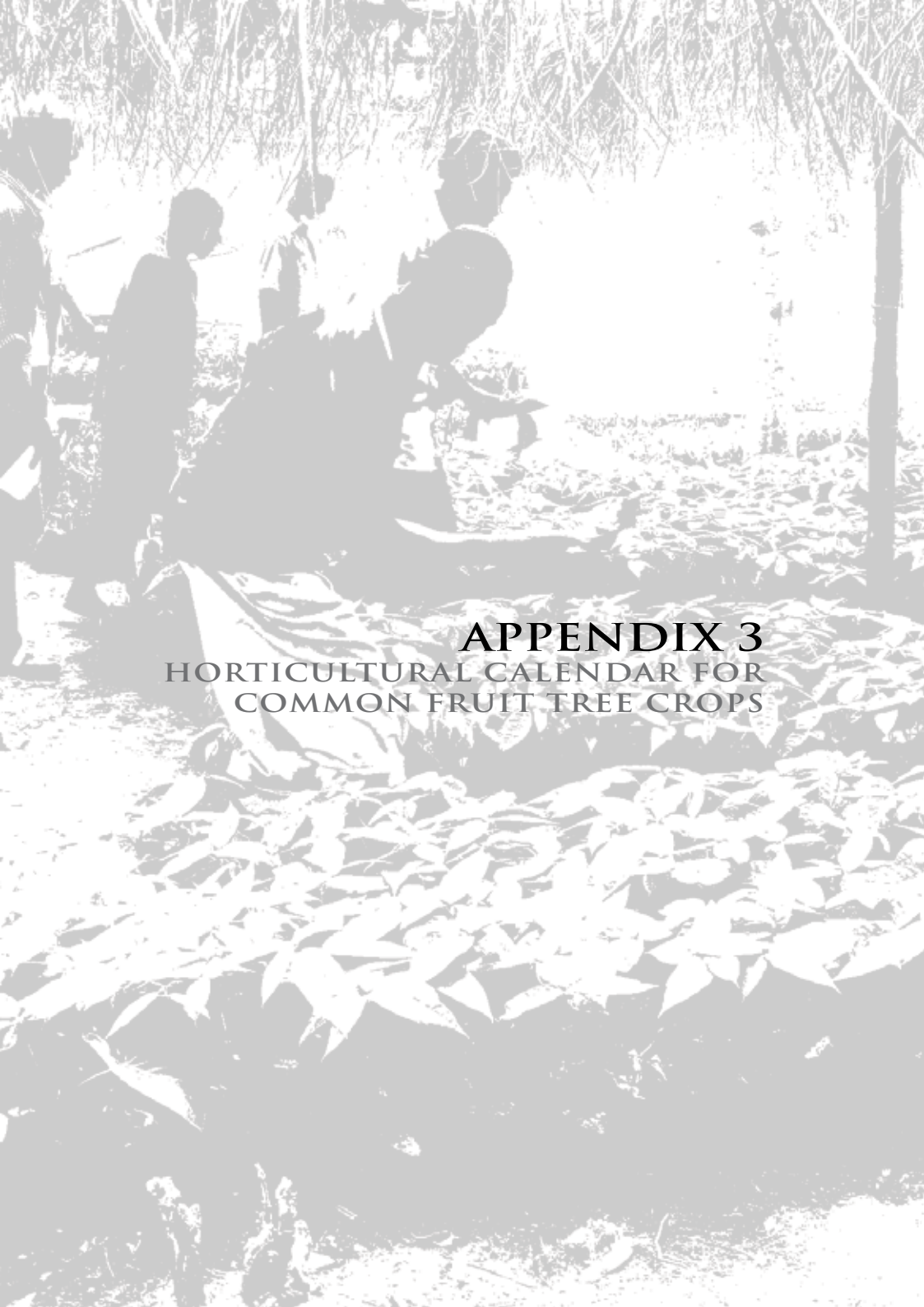
MAJOR USES AND FUNCTIONS											OTHER REMARKS
FODDER	WINDBREAKS	BEE FORAGE	LIVE FENCE	SHADE TREE	FIBRE	WASTELAND RECLAMATION	SHELTERBELT	MEDICINAL	TIMBER	ORNAMENTAL	
								✔	✔		Threatened species.
									✔		A large tree up to 35 metres with grey trunk, slightly buttressed. The pulp is eaten although bitter and acrid with a turpentine flavour. Especially valued for their subtly aromatic fat- and protein-rich nuts. Hardwood.
									✔		The flesh is eaten. Kernel can be used as soup condiment and sources of oil, wood for tools handles and utensils. Very common in Volta region.
								✔	✔	✔	Threatened savannah species.
								✔			Fruit and bark drank as medicine.
								✔			Used in traditionnal medicine, antioxidant and antibacterial.
✔	✔			✔							Cash fruit crop. Common in home gardens.
									✔		Threatened forest species.
✔											Nitrogen fixing and thrives well in Humid conditions.
		✔	✔			✔		✔			Flowers, leaves, roots and young pods use as food and medicines. It is drought-resistant.
					✔						Cash fruit crop. Common in home gardens.
		✔						✔			Edible leaves and seeds.
									✔		A commercial timber of West Africa, used for mortars.
✔			✔				✔				Good for alley cropping.

SPECIES		MA						
BOTANICAL NAMES	ENGLISH(E) EWE(V) TWI(T) GA(G) HAUSA(H) DAGBANE(D)	FOOD AND FRUITS	SOIL CONSERVATION	SOIL FERTILITY	FUELWOOD	DYES	GREEN MANURE	CONSTRUCTION & CRAFT-MAKING
Parkia biglobosa	West African locust bean(E), Ewo(V), Dawadawa(T), Atzomi(G) Doo(D)	✔	✔	✔				✔
Persea americana	Avocado pear(E), Paya(T/G/V)	✔						
Pleiocarpa mutica	(O)kanwen(e)/Kanwin(i)(T)							
Psidium guajava	Guava(E), Oguawa(T), Gowa(G), Goa(V)	✔			✔			
Pycnanthus angolensis	African nutmeg(E), Otie(T), Oti(G)	✔			✔			✔
Ricinodendron heudelotii	Wamma(T)	✔						
Senna siamea	Black wood cassia(E), Sangarati(V)		✔	✔	✔			✔
Spathodea campanulata	African tulip(E), Adatsigo(V), Kokoonsu / kokoanisua(T)			✔	✔			
Strombosia glaucescens	Afena(T)							
Tectona grandis	Teak(E), Bimbol(V), Alura(D)				✔			✔
Terminalia catappa	Indian almond(E), Yevuzi(V)	✔			✔	✔		
Terminalia ivorensis	Single Wood(E), Dzogbedodo(V), Emire(T)				✔			✔
Terminalia superba	Afara(E), Kangblale (V), Ofram(T/G)		✔		✔			✔
Tetrapleura tetraptera	Prekese (T)	✔						
Theobroma cacao	Cocoa(E), Kookoo (T/G/V)	✔						

AJOR USES AND FUNCTIONS											OTHER REMARKS
FODDER	WINDBREAKS	BEE FORAGE	LIVE FENCE	SHADE TREE	FIBRE	WASTELAND RECLAMATION	SHELTERBELT	MEDICINAL	TIMBER	ORNAMENTAL	
✔	✔	✔	✔	✔		✔	✔	✔			Seeds fermented and used as condiment and bark used as medicine.
✔		✔									Edible fruits and fodder leaves.
✔											Edible fruits, fodder leaves and fuelwood.
				✔					✔		Local construction. Important multipurpose tree specie.
✔											A tree with many uses that should be domesticated and cultivated; Kernel with high nutritional interest.
	✔	✔				✔	✔		✔		Good for woodlots.
✔	✔			✔							
									✔		Used for electric poles.
	✔								✔		Used for live fencing.
											Edible nuts.
				✔					✔		Fast-growing, high forest species.
				✔					✔		Fast-growing, high forest species.
								✔			Pods and bark use as medicine and spice. Used by nursing mothers to heal internal wounds after birth & promote breast milk.
		✔									Young pods eaten as vegetable. Seeds processed into chocolate and other products.

SPECIES		MA						
BOTANICAL NAMES	ENGLISH(E) EWE(V) TWI(T) GA(G) HAUSA(H) DAGBANE(D)	FOOD AND FRUITS	SOIL CONSERVATION	SOIL FERTILITY	FUELWOOD	DYES	GREEN MANURE	CONSTRUCTION & CRAFT-MAKING
Tieghemella heckelii	Baku or Cherry Mahogany (E)	✔						
Trema guineensis	Wadza wadza(V), Seseaa(T)			✔	✔			
Trichilia heudelotii	Tannuro(T)				✔			
Triplochiton scleroxylon	Obeche(E), Wawa(T/V/G)							✔
Vitellaria paradoxa	Shea(E), Nkudua(T), Nku(G) Kadainya(H), Yorkuti(V), Taanga(D)	✔	✔		✔			
Voacanga africana	Bonawa(T)							
Xylopia aethiopica	African spice tree(E), Kalè(V), Hwenetia(T)	✔			✔			✔

MAJOR USES AND FUNCTIONS											OTHER REMARKS
FODDER	WINDBREAKS	BEE FORAGE	LIVE FENCE	SHADE TREE	FIBRE	WASTELAND RECLAMATION	SHELTERBELT	MEDICINAL	TIMBER	ORNAMENTAL	
									✔		Important timber tree threatened by habitat loss. Often up to 45 m tall.
✔				✔							Thrives well under humid conditions.
				✔							Interesting for woodcarving.
									✔		Irregular seeding.
✔	✔			✔							Savannah species.
				✔				✔			Highly prolific species, especially on the coast.
								✔			Spice in soups.



APPENDIX 3

HORTICULTURAL CALENDAR FOR COMMON FRUIT TREE CROPS

MONTHS OF THE YEAR	AVOCADO (PEAR)	CITRUS (AKUTU)	COLA (BESE)
JANUARY	• Planning and procurement of nursery inputs. • Grafting of seedlings from previous year • Irrigation • Crop protection	• Procurement of farm inputs • Sowing of seeds in the pre-nursery • Irrigation • Crop protection	• Planning and procurement of nursery inputs • Filling of nursery bags • Potting of seeds • Irrigation of potted seeds and seedlings
FEBRUARY	• Grafting continues • Field preparation e.g. stumping, clearing • Cultural practices	• Budding of matured seedlings from previous year • Cultural practices • Pruning of budded seedlings	• Irrigation continues • Nursing of seeds in polybags continues
MARCH	• Field preparation continues • Marking out of field and holing	• Pruning and budding continues • Irrigation	• Cultural practices at the nursery • Marking out of field and holing
APRIL	• Grafting continues • Transplanting of matured grafted/un-grafted seedlings from previous year to the field	• Pruning continues • Potting of young seedlings • Transplanting of matured budded seedlings onto the field	• Transplanting of matured grafted/ un-grafted seedlings from previous year to the field • General maint- enance of nursery and field
MAY	• Transplanting continues • General maintenance at both nursery and field	• Crop protection at both field and nursery • Potting and field transplanting continues	• Grafting of new seedlings • Transplanting continues • Cultural practices
JUNE	• Transplanting continues • Fertilizer application at both nursery and field	• Transplanting continues • Fertilizer application at both nursery and orchard	• Fertilizer application • Crop protection • Transplanting continues

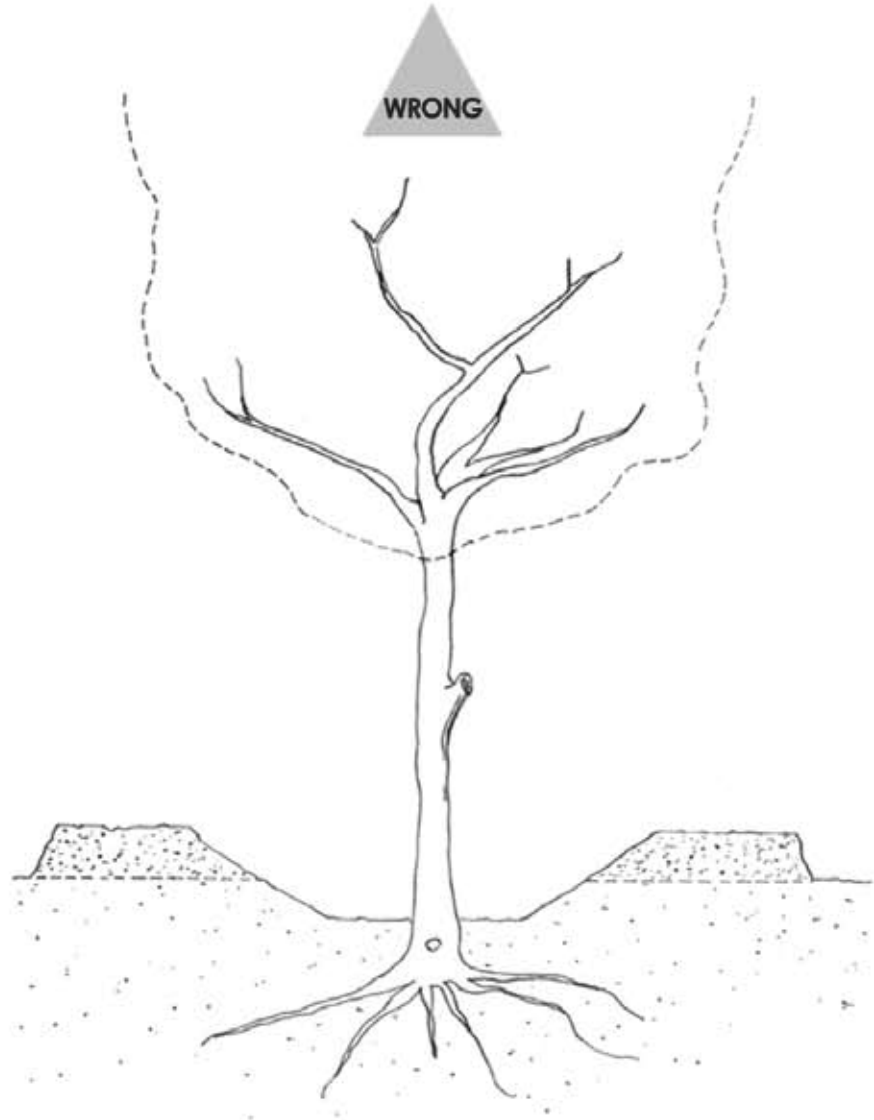
IRVINGIA WOMBULU (ATOR)	MANGO (AMANGO)	PAWPAW (BOFRE)	PLANTAIN BANANA (KWEDU)
• Planning of nursery operations • Procurement of farm inputs • Nursery preparation	• Procurement of farm inputs • Cultural practices – mulching • Grafted seedlings at the nursery • Irrigation, pest and disease control	• Procurement of inputs • Filling of nursery poly-bags • Nursing of pawpaw seeds in nursery bags	• Planning of nursery operations • Multiplication of sucker at the nursery
• Fruit/Seed collection • Fruits could be fermented or de-pulped	• Field preparation e.g. stumping, clearing	• Nursing of pawpaw seeds continues • Shade construction • Watering and general maintenance	Nursery operations continue
Nursing of seeds in poly-bags	• Land preparation continues • Digging of holes, etc.	• Field preparation • Marking out of field and holing	• Field preparation • Marking out of field for transplanting
Maintenance of nursery seedlings	Transplanting of established grafted seedlings	Transplanting of pawpaw seedlings to the field	• Matured suckers transplanted • General maintenance at both nursery and field
Collection of Irvingia gabonensis stones for nursery	• Weed control • Raising nursery beds for restocking	• Weed control on the field • Fertilizer application	• Transplanting to the field continues • Weeding if necessary • Fertilizer application
• Budding of seedlings • Field planting of matured seedlings	• Fertilizer application • Collection of mango seeds for nursery	Cultural practices like mulching, irrigation, etc.	• Field transplanting continues • General farm maintenance

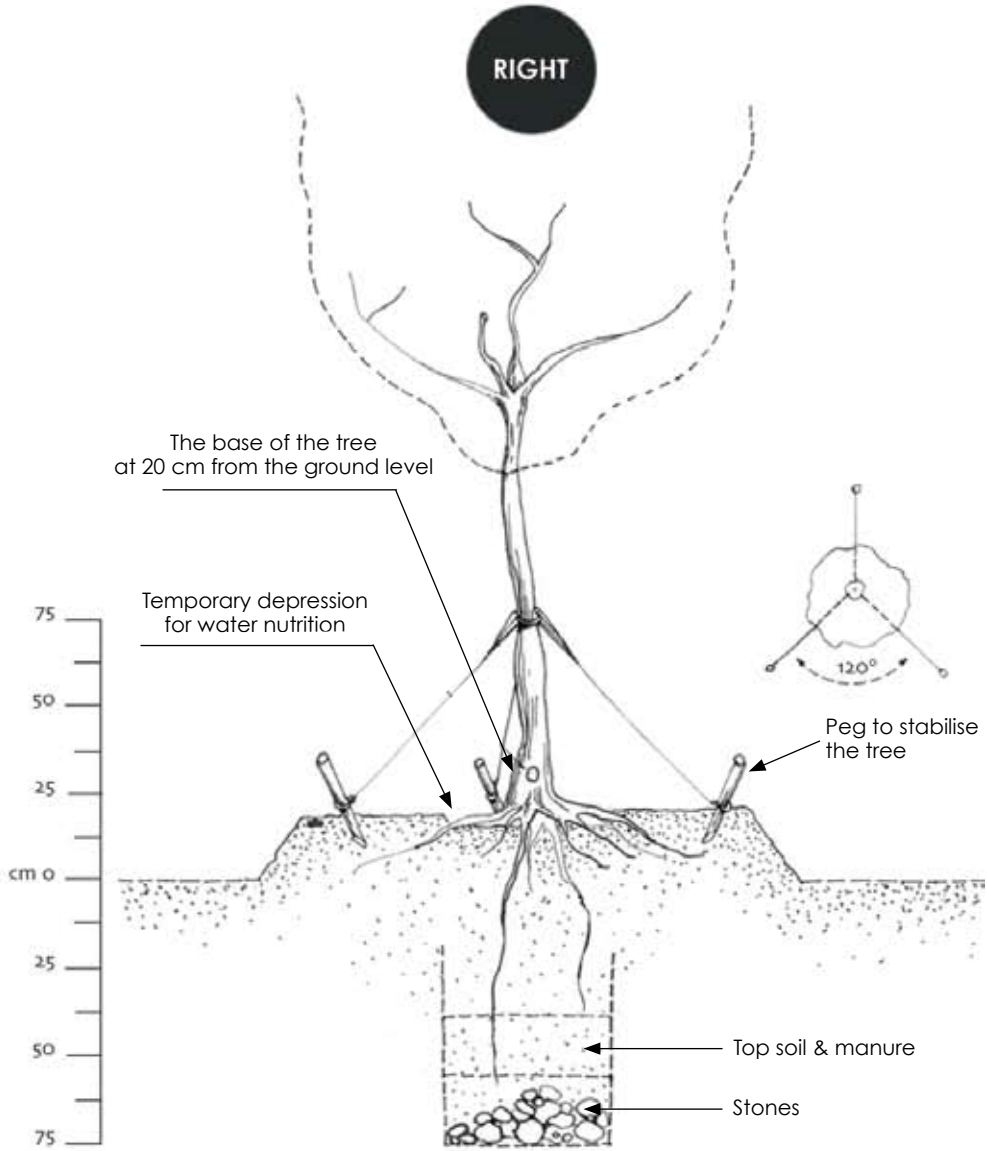
MONTHS OF THE YEAR	AVOCADO (PEAR)	CITRUS (AKUTU)	COLA (BESE)
JULY	• Cultural practices • Transplanting may continue	• Cultural practices • Transplanting may continue	• Transplanting may continue • General field and nursery maintenance and mulching
AUGUST	• Weed control • Crop protection • Fertilizer application • Irrigation if necessary	• Weed control • Crop protection • Fertilizer application • Irrigation if necessary	Irrigation if necessary
SEPTEMBER	• Collection of seeds and processing • Potting of selected seeds • Replacing dead seedlings on the field	• Weed control • Crop protection	• Replacing dead seedlings on the field • General maintenance operations • Filling of polybags
OCTOBER	Seed collection and potting continues	• Weed control continues • Mulching and pruning of rootstocks • Irrigation	• Fruit collection and processing • Potting of seeds • Irrigation
NOVEMBER	• Seed collection and potting continues • General field maintenance operations • Fire-belt creation	• Creation of fire-belts. • Harvesting • Seed extraction and processing • Seed sowing • Budding begins • Irrigation	• Fruit collection and potting continue • Cultural practices at both nursery and field
DECEMBER	• Cultural practices at both nursery and field. • Procurement of necessary inputs for next season nursery	• Seed sowing at the pre-nursery • Budding • Weed control • Disease Control • Irrigation	• Fruit collection and potting continue • Cultural practices at both nursery and field

IRVINGIA WOMBULU (ATOR)	MANGO (AMANGO)	PAWPAW (BOFRE)	PLANTAIN BANANA (KWEDU)
• Budding continues • Fertilizer application	• Weed control • Nursing of mango stones at nursery	Second fertilizer application	• Second fertilizer application • General farm maintenance continues
General field and nursery maintenance and mulching	• Maintenance of rootstock • Grafting of matured seedlings • Crop protection on both field and nursery	• Weeding and irrigation if necessary • Collection of mulch	• Crop protection • General field maintenance continues
General field and nursery maintenance and mulching continue	• Replacing dead seedlings on the field • General maintenance operations	• Mulching • Last fertilizer application • Crop protection if necessary	• Staking or propping. • General field maintenance continues
General maintenance operations	• General field maintenance operations • Fire-belt creation	• Fruits mature for harvesting • Mulching continues	• Harvesting of mature fruits begins • Mulching of fruiting stands at the nursery
• Crop protection. • Application of mulching materials on the field • Rootstock management at the nursery for next year budding	• Crop protection • Fire-belt creation continues	• Harvesting of mature fruits • Irrigation if available	• Staking or propping of fruiting tress • Harvesting of mature fruits continues
• Planning nursery / farm operations • Procurement of necessary inputs	• Procurement of inputs for the following year operations • Crop protection continues	• Pawpaw seed extraction • Procurement of nursery materials e.g. poly-bags, fertilizer • Planning for next season nursery	• Crop protection • Collection of desired suckers for multiplication • Procurement of necessary inputs for next season nursery

APPENDIX 4

TECHNIQUES FOR PLANTING AND TENDING TREES


WRONG


RIGHT
The base of the tree
at 20 cm from the ground level
Temporary depression
for water nutrition
120°
Peg to stabilise
the tree
75
50
25
cm 0
25
50
75
Top soil & manure
Stones

Some native fruits

MINCHINGORO
Garcinia kola

NUTS FRUIT

WAMMA
Ricinodendron heudelotii

FRUIT KERNELS

ATOR
Irvingia gabonensis

KERNELS

BESI
Cola nitida

NUTS COCOA POD

BAKU
Tieghemella heckelii

SEEDS

SCALE 5 cm 5 cm

PUBLISHED SECOND TRIMESTER 2010 BY

Pro-Natura International
Member of IUCN, The World Conservation Union

15, Avenue de Ségur, Paris 75 007 France
Tél : + 33 (0)1 53 59 97 98
Fax : +33 (0)1 53 59 94 46
Email : pro-natura@wanadoo.fr
Web : http://www.pronatura.org
International Charity (Association Loi de 1901 JO 23.09.92 N° 39)