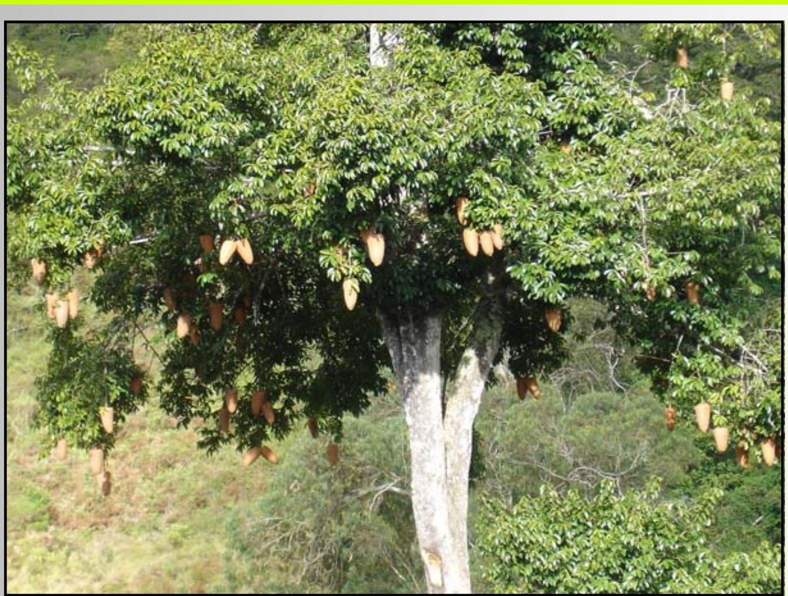
Allanblackia propagation protocol



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Preface

This protocol has been prepared for use by Allanblackia domestication implementers and nursery operator on seedlings production and training. It is intended as a practical guideline to cover some of the basic principles of production of quality seedlings and clones. The protocol is our first attempt to bring together the knowledge both within and outside Allanblackia domestication team in seedlings production. The overall program goal is to provide sufficient germplasm quantities and in a timely manner for planting; at the same time, supplied planting material should be capable of consistently producing good quantities of high quality oil.

As part of Novella Africa programme on 'Domestication of AB Trees in Africa', ICRAF aims to develop jointly, with national partners in participating countries, options for appropriate propagation and management practices for AB trees, to enhance the efficiency, level and stability of tree production. Its outputs are globally applicable or adaptable propagation and nursery management guidelines. It is in the context of this project that this protocol is written to give guidelines on conducts research and seedlings development activities. Allanblackia seedling industry is not well established and there is a need to organise better the overall nursery system so as to improve the availability of seedlings and promote appropriate site and species combinations. With seed propagation technique turning as difficult to implement, vegetative propagation is seen as a possibility to select superior germplasm and bring this important resource into the farmers' fields.

The manual has been developed with input from many Allanblackia domestication persons from Cameroon, Ghana, Kenya, Nigeria and Tanzania and I thank all contributors for their efforts that have allowed me to put together this document. No thanks would be complete without recognizing Dr. Ian Dawson for tireless edited this manual. I hope that you will find it useful and I would be pleased to receive comments and suggestions to improve and revise it.

About this protocol

This protocol is an application of practice in Allanblackia domestication team as experienced and practiced by the research and development programme in Cameroon, Ghana, Nigeria and Tanzania. It is a research and development tool with particular biases on participatory domestication as basic foundation of quality and quantity seedling development.

The preparation of this protocol been developed into modules by its scientific staff in support of various groups participating in domestication of this species. This training manual has been developed for the following reasons:

- To support the various domestication research and development activities.
- To provide reference material for participating institutions and extension agents when they are propagating AB trees.
- To provide guidelines and resource material for managers and/or resource persons who wish to organize a training course in the future.

In producing this protocol reasonable care has been taken to ensure that all statements represent the best information available. ICRAF and its partners/collaborators shall not be liable on any ground for any loss, damage, or liability incurred as a direct or indirect result of any reliance by any person or institution upon information contained or opinions expressed in this work. The opinions or views expressed in this publication are those of the author alone and do not imply any opinion whatsoever on the part of the World Agroforestry Centre (ICRAF) or its partners or collaborating institutes. Comments and suggestions are invited and can be addressed to the editor(s) or to the author(s) themselves. These protocol notes are periodically reviewed and updated to reflect advances in this species research and development.

Partners in Allanblackia domestication research and development include:

- Amani Nature Reserve (ANR)/Forest and Beekeeping Division (FBD), Tanzania
- Forestry Research Institute of Ghana (FORIG), Ghana
- Forestry Research Institute of Nigeria (FRIN), Nigeria
- Institute of Agricultural research for Development (IRAD), Cameroon
- International Tree Seed Centre (ITSC), Ghana
- Tanzania Forest Research Institute (TAFORI), Tanzania
- Tanzania Forest Conservation Group (TFCG), Tanzania
- The World Conservation Union (IUCN)
- Unilever
- World Agroforestry Centre (ICRAF)
- Agricultural Research Stations (ARS)
- Edo State Agricultural Development Programme (EDO ADP), Benin City, Nigeria
- International and national NGOS

Acronyms

AB	Allanblackia species
AHI	African Highland Initiative
ANR	Amani Nature Reserve
ARS	Agricultural Research Station
ICRAF	World Agroforestry Centre
FBD	Forest and Beekeeping Division
FORIG	Forestry Research Institute of Ghana
FRIN	Forestry Research Institute of Nigeria
IRAD	Institute of Agricultural research for Development
ITSC	International Tree Seed Centre
IUCN	The World Conservation Union
NGO	Non-Governmental Organization
SNV	Netherlands Development Organization
TAFORI	Tanzania Forestry Research Institute
TFCG	Tanzania Forest Conservation Group
WCA	West and Central Africa

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Chapter 1.0: Introduction

1.1. Importance of Allanblackia (AB) tree

Allanbackia species are multi-purpose indigenous fruit trees that could be rapidly domesticated and can be viewed as potentially important source of alternate income to farmers. The seeds of AB are rich in oil. A new agri-business based on the oil is being developed in Ghana, Nigeria, Cameroon and Tanzania. This rural based enterprise would not only increase livelihood opportunities for farmers but also ensures retention of trees on-farm for ecosystem functioning.

Very large quantities of both seed- and vegetatively-propagated plants will be required to supply this demand for planting materials; a significant number of nurseries will need to be established in each country participating in the initiative. Nurseries will need to operate at different geographic scales, in a spectrum from a few large centralised nurseries at the macro-geographic level (supplying material by country region), through medium-scale community nurseries (supplying material at a local landscape level), down to many small-scale farmer initiatives at a micro-geographic level (farmers raising material for their own farms and those of their neighbours).

1.2. Description of Genus Allanblackia

Allanblackia is a tall evergreen montane rain-forest tree belonging to family Clusiaseae, more than 20 meters high with simple, opposite leaves and white, pink or red, very fragrant flowers. The mature fruits are large ovoid brown berry-like drupe containing brown seeds. It is found at an altitude of 400-1800 m and mean annual rainfall ranging from 1200-2400 mm.

AB has the largest fruits of all plants in the African rain forests. Given its high quality oil and a guaranteed market, it has been recommended for planting to improve the income of the local people in its native range and for environmental protection.

Allanblackia stulhmannii fruiting heavily in East Usambara, Tanzania

Allanblackia floribunda fruiting heavily in Cameroon

1.3. Importance of propagation protocol

The need of genuine and sufficient quantity planting materials for rapid expansion, replanting, interplanting, etc; ICRAF and its domesticating partners are selecting and developing superior planting materials to help farmers raise the planting materials in four countries (Cameroon, Ghana, Nigeria and Tanzania) in Africa. The major research thrust of the Allanblackia domestication programme is to develop production technology for the selection of suitable varieties and standardization of agronomic practices or techniques. A objective of the protocol is to provide information on production of germplasm in sufficient quantities and in a timely manner for planting; at the same time, supplied planting material should be capable of consistently producing good quantities of high quality oil. Taking into account to help and build capacity for nursery operators, managers and farmers in order to raise quality and quantity planting materials for rapid replanting and interplanting. This would help the Allanblackia industry at large in meeting the future demand of nuts for oil production in international markets in terms of quality as well as quantity.

Researches on the vegetative propagation of Allanblackia have been initiated for a number of reasons. First, the difficulties in handling seed, especially very slow germination, mean that alternative means of propagation are desirable. Second, the clonal nature of vegetative techniques brings certain clear advantages, including the opportunity while planting to control the female to male ratio of *Allanblackia* trees on farms (the genus being dioecious), and the ability to sample and then multiply 'true-to-type' elite varieties that have superior production characteristics (the issue of elite material and the efficacy of field selection is addressed separately below). Finally, a concern with *Allanblackia* grown from seed is the relatively long time taken to produce fruit; experience from other tropical fruit trees suggests that the period to maturation may be reduced by at least half through vegetative propagation, allowing on-farm production from planted stands to begin considerably earlier than would otherwise be the case.

1.4. Importance of Manual

Early in the *Allanblackia* initiative, the need for planting rather than reliance on sourcing oil solely from natural stands was identified as a crucial task. The major concern then is the development of early bearing varieties and methods for propagation. The main objective of this manual is providing guideline on the identification and selection of superior materials from within the existing wild populations before breeding. Thus these guidelines for example provides a breeder with information on how to select an individual tree with superior yield, in terms of fruit production, quantity and quality of oil could be mass produced by vegetative propagation. Through this, it is possible to achieve rapid and substantial genetic improvement in yield and oil production.

Therefore, this manual strengthens the local institutions in implementation of their activities at village and/or county levels by providing training in planning and management. Readers of these guidelines are encouraged to improvise and adjust their approach to suit the local social and biophysical environment. The intention is to review the guidelines from time to time in response to changing advancement and improvising new technology to the project. It has been suggested that *Allanblackia* raised from seed in a farm environment should fruit after ~ 12 years (though some farmers think faster), whereas extrapolations from other species would suggest that material propagated vegetatively will fruit before its 5^{th} year.

Chapter 2.0: Tree nursery

A nursery is a place for raising young plants (seedlings) with special care until they are ready or large enough for transplanting into the field.

2.0 Why tree nurseries?

Many people depend on forests and trees to meet various needs. With growing demand for AB nut for oil production and the nuts are unsustainably harvested from natural stands currently. Many farmers want to AB trees but cannot readily obtain quality tree seedlings. Establishing a tree nursery can help to meet this demand and provide farmers with extra income.

2.1 How to set up a tree nursery

2.1.1 Site Selection

The selection of the site is very important, because it has great influence on the total production. A good nursery site should have reliable water supply, easy access for transport, good drainage, good security, sheltered from prevailing winds, not over shaded by trees, large enough to accommodate nursery soil, sheds, and nearness to the source of growing and rooting media.

2.1.2 Nursery Layout

The required size of nursery depends on the area available but also can be worked out according to the following formula:
(a) Production area accounts for 60% of total nursery areas and includes:

- ⇒ Sowing area and propagators section;
- ⇒ Pot beds, weaning chambers and section;
- ⇒ Pot stretching area and shade; (so called potting or pot filling area);
- ⇒ Seedlings classifying area before delivery.

(b) Production support areas accounts for 40% of total nursery area. It covers pot bed; access path system; storage area, and shelter.

Central Nursery Amani Nature Reserve, Tanzania

Low shed in Amani Nature reserve, Tanza-nia

2.1.3 Making a shade roof

A roof is set up, 1.8-2.0 m above the ground. Roofing material should be in pieces, small enough for them to be removed easily to allow watering and exposure to sunlight.

Clonal nursery shed should be constructed to allow good aeration, easy working environment and good drainage. Overhead shed should be placed two metres high and should allow penetration of 25-40% of full light. Materials to be used to construct shades are poles and net/thatch/grasses which are durable, providing uniform light and easy to adjust. Strong poles are usually erected vertically to support a thatch of durable materials which can be adjusted to distribute light uniformly. Shade is varied by taking out and rearranging the shade material.

2.1.4 Types of shed

a) Low level shed consists of 1.3 m high bamboo basket, thatch or weeds work frames laid across the bed fences with the uprights high enough to give a clearance of 25cm above sleeve tops. Shade is varied by raising the frame on a stick support.

b) Overhead shed is a roof like structure supporting material like split bamboo, thatch or weeds, high enough to allow all concerned to walk upright in the drains. Shade is varied by taking out and rearranging the shade material.

It is good for small-scale grower to use locally available material (grass, fern, palm leaves, bamboo, fern or banana leaves for shading). It is cheap to construct in terms of labour and material costs. The plants will take less time prior to planting out in the field.

Low Shed

- External dimensions 1.3 m x 4½ m long
- Internal 1 m x 4 m
- Top shade height 1 m

High shed

- External 2½ m x 6 m
- Internal 1½ m x 4 m
- Top shade height 2½ m.

Note: *Allow a ventilation of 30 cm at the top in low shade.*

2.1.5. Making the nursery beds

(a) General seedling beds

The bed should be 8-15 m in long, 1-1.2 m in width, and 10-15 cm in high. Walking paths 30-35 cm wide should be constructed between beds, to allow for easy access in the management of the nursery.

(b) Clonal beds (low tunnelling)

Convenient clonal bed size should be 1 m by 5 to 30 m (1125-6750 sleeves approx.). Bed surface cambered 3 cm, raised eight to ten centimetres above the ground and surrounded with drains 30 cm deep and 30 cm wide (minimum). Construct a fence surrounding each bed about 20 cm high above ground, holding sleeves upright, by weaving split bamboo/sticks between upright pegs set 0.5 m apart along the edge of the bed.

2.2.0 Clonal nursery

2.2.1 Nursery

The main steps of clonal nursery establishment are mother bushes/coppiced stump, site selection, site clearing, soil selection, plant shed construction, preparing nursery beds, construction of soil shed, pot filling, stacking, cuttings preparation, planting and care after planting.

2.2.2. Materials requirement

Materials needed are polythene tubes, polythene sheets, fungicides, razors, plastic basins or buckets and insecticides.

2.2.3. Size of polythene tube

The size of the sleeve will depend on the size of plants required by the grower. Larger plants like AB will require larger sleeves and vice versa. The standard polypots for AB species is 10-12.5 cm (4-5 inches) laid flat and 18-30 cm (7-12 inches) long as the plants stay long in the nursery. The polypot should have drainage holes in the lower half of the pot and at the bottom. If drainage holes are not adequate, excessive water accumulates and causes death.

2.2.4. Media Selection

Both top and subsoil are needed. Sub soil is the rooting medium/substrate with a pH of 4.5 to 5, low in organic matter and high water absorption is appropriate.

Top soil helps growth of the seedling after root formation. Good forest loamy topsoil with high fertility and pH of 4.5-5.5 is ideal for seedling growth.

It is been found that addition of soil under AB trees to the potting media also promote the growth of AB seedlings.

Media and additives needed

- Forest soil
- Red acid soil
- Triple super phosphate (TSP)
- Muriet of potash (MOP)

Note: Unless an extension agent has conducted trials to find out whether the soils used in the area require any additional fertilizers, it is suggested that the rates shown below for east Usambara should be used.

2.2.5. Pot preparation

Polyethylene/plastic bags or sleeves (12 x 18 cm) are used as pots. Several holes are needed in the bottom part of the bag for drainage. A mixture of soil to be put into the bag or pot is prepared depending on the region/site or availability of the media. The pots or plastic bags are placed firmly on the nursery beds (5-30 m in length and 1-1.2 m in width).

2.2.6. Polythene tent

To build one low tunneling bed 1.2 m wide, 3 m long and 0.5-0.75 m high, you require:

- 30 bamboos 7 m long and 8 meters of flexible stakes;
- 3 metres of locally available fibre or sisal twine;
- 5 metres of transparent polythene sheet (1.5-2 m wide);
- 10 wheelbarrows of red soil;
- 25 wheelbarrows of forest soil
- 675 5 by 7 polythene tubes
- 1200 grams of Tripple super phosphate (TSP) and
- 600 kilograms of Muriet of potash (MOP)

Flexible bamboo/woody hoops are bend across the bed at 50cm space and the polythene sheeting is then stretched over the semicircular hoops that are 30 –40 cm above the sleeves level at the middle

2.2.7. Fertilizer application

Responses of fertilizer which are mixed with a rooting medium depend on the kind of soil used. Some soils are rich in nutrients and thus do not need additional fertilizers.

2.2.8. Pot filling

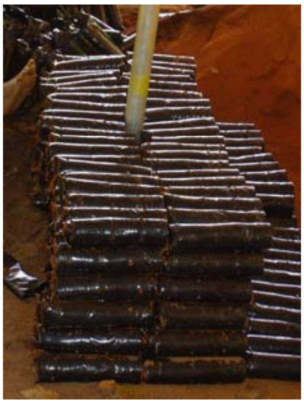
The commonly used method in pot filling is two-soil layer method. The topsoil is put into the pots first, which should be filled to a height of 2/3 of the polythene tube.

The polythene tubes are then filled with subsoil at the top left 1/3 of the polythene tubes. The soil in the sleeves should be fairly firm but should never be packed brick hard. The pots containing the substrate should be carefully transported to the beds and stacked neatly in lines. Maximum use of available space should be considered at stacking.

Alternatively, the topsoil is put or filled to 2/3 the pots first the height of polythene tubes. The pots containing the topsoil is then carefully transported to the beds and stacked neatly in lines. The subsoil is then filled to a height of 1/3 of the polythene tubes (above the top soil).

2.2.9. Stacking

Media preparation



Potting

Stacking

Arrange the sleeves in the nursery bed such that every 225 sleeves occupy 1m2 (15 sleeves per line with polytubes of 5 by 7" size).

2.3.0. Building a non-mist propagator

Materials needed for constructing non-mist propagator are:

I. wooden frame;

II. a thick grade of clear (or white) polythene sheet;

III. stones, gravel, sand; (below rooting medium) as a filling materials for better drainage;

IV. nails, office stapler and drawing pins to join and fix polythene sheeting, hammer, hinges + screws, clips to secure cover against storms, bamboo or plastic pipe as a gauge for checking water level.

Propagator is a simple frame covered with clear (or white) polythene sheet, and contains a reserve of water below a moist rooting medium.

To build one wooden poly-propagator 1 m wide, 3 m long and 0.5–1 m high, with three compartment of 1m^2 each you require:

- *25 metres of planks or Wood and 6 laths;*
- *1 kg of 80mm nails, 6 hinges and 18 screws;*
- *15 metres of transparent polythene sheeting (2 m wide);*
- *3 wheelbarrows of quarry stones and gravel each;*
- *2.5 wheelbarrows of sharp sand*
- *2.5 wheelbarrows of decomposed sawdust*
- *1 wheelbarrow of soft sand.*
- *1 m of tube (with diameter of 5 cm)*
- *1 packet of chair nails (about 1 kg)*

All the filling material needs to be thoroughly washed before use

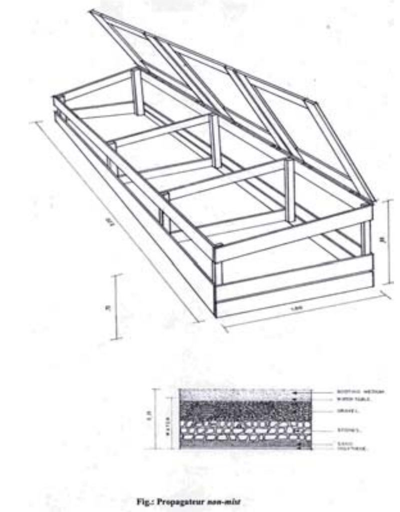
Make wooden framework to your desired length but a convenient size is often about 1 m wide × 2–4 m long. The height should be between 0.5 and 1 m, with a sloping cover. Attach the polythene sheeting on the inside of the framework, making doubly overlapping joins between one sheet and the next, and so that the wood is not permanently wet. Use a single piece of sheet without holes for the whole of the base plus the lower 0.3–0.4 m of the sides. Leave the sheet loose on the side that rests on the ground it will hold the filling without excessive strain. Put a short piece of plastic pipe or bamboo vertically in the corner (25–30 cm long and about 5 cm in diameter). This will let you check the correct water level easily, and add water if needed, without soaking the rooting medium.

Dig four small holes to anchor the ‘legs’ at the corners of the propagator. Level out the ground between these holes, and spread sand to protect the polythene sheet from getting pierced or stretched. Make sure the propagator stands level, and then fix it in place with stones;

Thoroughly wash the filling material before use. Add carefully the filling materials, so as not to damage the polythene sheet:

- ⇒ a thin layer of sand;
- ⇒ a thick layer of stones (8cm high);
- ⇒ a thick layer of gravel (11 cm high);
- ⇒ add water to the level of gravel.
- ⇒ Add a thick layer of sand (about 15–20 cm depth of rooting medium on top). It should be moist but not waterlogged.

Propagators showing layers of media



Model propagator with dimensions shown
(Adapted from ICRAF, Cameroon)

Chapter 3.0: Propagation by seeds

Allanblackia species has proved to be difficult to grow from seed, because the seeds do not germinate quickly. Use of growth hormones (e.g. gibberellic acid - GA3, potassium nitrate, etc) to break dormancy does not work. Unlike other difficult species, there is **no confirmed special seeds treatment** developed so far. Recently, removal of the whole testa from the seeds and subsequently placing the seeds in a black plastic bag and then applying moisture triggered fast germination in this species. In Nigeria, germination was obtained 3 to 6 months after sowing in the nursery by removing seed testa completely and sowing the seeds on white river sand and covering the germination trays containing the seeds with humidity chambers.

3.1. Fruit maturation

⇒ The tree usually fruits twice a year.

⇒ The peak season is from November to March, which synchronizes with the flowering season, second season is from May to July.

⇒ Mature fruits usually fall from the tree and split.

3.2. Collection handling and processing

⇒ Good harvest is during the peak season.

⇒ Select healthy, mother trees with desirable traits or characteristics

⇒ Collect fruits from ground only immediately they fall off the tree (see picture below).

⇒ Allow space for aeration during transportation.

⇒ On arrival at the site or nursery, store fruits under shade in open containers for at least a week for post maturity and making the pulp softer.

Variety of mature fruits found in East Usambara, Tanzania

Bulked fruit of Allanblackia parviflora, Nigeria

Arrangement of seeds in the fruit of Allanblackia stulhmannii

⇒ Extract by smashing the fruit between hands and separate the seed from the pulp. Place the extracted seeds in water to leach any chemicals and to retain the softness of the testa.

⇒ Clean the seeds in running water to remove the pulp and other chuffs to avoid pathogenic infection.

3.3. Seed pre-treatment

⇒ Remove the testa immediately after extraction using a knife.

⇒ To ease the testa removal, bury the seeds for sometime (2-4 weeks).

⇒ Place the treated seeds in water to leach inhibitors for 1 hour.

⇒ Now the seeds are ready for sowing.

3.4. Seed sowing

⇒ Seeds with or without testa can be used.

⇒ There are two methods used to sow treated seeds (testa removed): *use of polythene sheet and sowing seeds in a bed with sand and covering them with polythene sheet to maintain the temperature*.

Seed extraction from *A. stulhmannii* fruit

Seed extraction of *A. parviflora*

Clean seeds ready for treatment or sowing

3.4.1. Method 1

⇒ Sow the treated seeds in the prepared sand seedbeds.

⇒ Place the sand over them and press the soil down firmly to ensure good contact between sand and seed. Sowing depth is 3-4 cm.

⇒ Water carefully.

⇒ Cover the seedbeds/benches with a polythene sheet or place containers in a greenhouse to hold the moisture and maintain the temperature above 25^{0}C. Remove the seeds to sleeves as they germinate, replace the cover. Water the bed if low in moisture.

⇒ Water and weed the beds as needed after transplant.

Seed treatment using knives

Seed treatment using knives

Treated seeds ready for sowing

3.4.2. Method 2

- ⇒ Put the treated seeds in a polybag (black or transparent) and spray a thin film with clean water to moisten them making sure you don't over water them to reduce rotting.
- ⇒ Tie the end of the poly bag; hang the bags under shade anywhere in the nursery.
- ⇒ Evaluate after four weeks and thereafter after every two weeks; make sure they do not dry out
- ⇒ Germination is expected from 4 weeks. Transplant and pot seeds with root length of about 4cm and above.

Note: Fifty seeds per black poly bag is recommended

During assessment of seeds in poly bags the following are observed.

- ⇒ Emerging of seeds roots from the seeds
- ⇒ Emerging of shoots alone
- ⇒ Emerging of shoots and seeds roots
- ⇒ If kept in the pots for a long time some of the roots will have root hairs on them.

If kept for a long time in the poly pots the rooted seeds tend to die.

All rotten seeds must be removed from the poly bags during assessment.

Seed pre-treatment is difficult and you can treat about 100-300 seeds a day if you are experienced. For mass production of seedling you can use seeds that are not decapped (seed testa removed).

Germinating seeds in a polybag, Ghana

Fungal infection in germinating seeds in a poly-bag, Tanzania

It has been observed that the seeds are attacked by fungi in most cases while germinating in polythene. This is usually due to contamination during removal of the testa or watering process. The water quantity is critical to the success of this method; the seed will die if too much water or too little water is applied.

3.4.3. Method 3

- ⇒ After extracting the seeds from the fruit and cleaned, place them in sawdust/sand and cover with polythene sheet completely to keep the environment warm or place the containers on a warm chamber and moisten the media with enough water.
- ⇒ Leave the seeds to germinate and check for germination regularly which should start after 3 months.
- ⇒ Check the moisture of the media regularly.

⇒ Transplant them into the polybags or sleeves as they germinate.

3.4.4. Method 4

⇒ After harvesting the fruit place them in a container/just on the ground and cover them completely with polythene sheet.

⇒ Water the fruits thoroughly

⇒ Leave the seeds to germinate; check for germinants after 2 month.

⇒ Transplant seeds as they germinate

3.4.5. Method 5

⇒ Collect mature and fallen fruits from selected female trees

⇒ Take fruits to nursery and allow to stay 5-7 days prior to extracting seeds

⇒ Extract seeds and wash in clean water

⇒ Remove seed testa completely

⇒ Sow in germination trays or boxes containing white river sand

⇒ Spray with clean water and cover with humidity chamber

⇒ Germination is expected within 3 months and may be completed in 6 months

Germinated seeds from seed bed ready for transplant to polybags in Tanzania

Germinated seeds from poly-bags method ready for transplant in Ghana

3.5. Transplanting and pricking out

⇒ Seeds usually germinate with root first.

⇒ If in a seedbed, prick out the germinated seedlings and transplant them into containers. Germination is noted by cracking of the media (substrate) in case of the sand.

⇒ Transplant them carefully, using a small stick or dibble. Do not damage the roots, to avoid shocking the seed.

⇒ For containerized plant, fill containers with soil mixture, make a hole in the middle of the container and place the roots straight down in the substrate.

⇒ Water the seedbed and containers after transplanting.

Transplanted seedling in Tanzania

A. gambonensis seedlings in the nursery , Cameroon

Seedlings ready for planting in the field in Tanzania

The success rate depends on the method used and the treatment done. In Ghana when using black polythene bags, a success rate of over 40% is reported. Other methods has reported a germination rate of less than 10% in most cases. After transplanting into the polytubes, a success rate of over 80% is recorded.

Chapter 4.0: Vegetative propagation

One of the biggest problems associated with domestication of AB is the multiplication technologies on a large scale for provision of enough and quality materials for planting. The common way by which plants regenerate naturally is propagation by seed. For research and rapid improvement of undomesticated species like AB, however, vegetative propagation methods offer several advantages. For example, a large variation in important product characteristics (e.g. fruit quality, bole straightness, and biomass) may be expressed in wild populations. Furthermore, individuals may be recognized within a population that produces a higher quality of the desired product(s) or services. It would therefore be advantageous to propagate these individuals vegetatively to 'capture' the genetic variation expressed, which may otherwise get lost or diluted during sexual propagation.

Successful vegetative propagation programmes would require development of appropriate environmentally controlled devices for maintaining optimum humidity, temperature and light. Further there should be a proper method to control the growth of pathogens. Two major methods used in vegetative propagation are hetro-vegetative (grafting) and auto-vegetative (rooting and cutting). Different methods of vegetative propagation used here are: cuttings, grafting, and marcoting.

Vegetative technique has many advantages compared with multiplication by seeds, as gain is likely to be greater if vegetative- rather than seed-based approaches to collection are used. However, it also has some disadvantages, therefore, be introduced only if suited to the local environmental and economic conditions.

4.0.1. Advantages of Vegetative propagation

⇒ Capturing the desirable traits and more uniform growth.
⇒ Yield higher
⇒ Earlier fruiting.
⇒ Easier harvesting as the trees are short.

4.0.2. Potential disadvantage

⇒ A nursery bed and weaning chamber (green house) is needed for the cuttings and grafting.
⇒ Transporting plantlets is an additional cost.
⇒ The planting season is critical and short.

Despite these concerns, it seems reasonable to assume, based on experiences with other indigenous fruit trees that suggest fruit trait heritabilities are reasonably high, that some level of genetic gain is possible through selection during collection from natural *Allanblackia* stands.

4.1. Cuttings

This could help pave the way for domestication of *Allanblackia*, a species that produces oily seeds that probably delay their ability to germinate easily. This has constraint to cultivating the tree in its native range. The work to develop vegetative propagation techniques for this species is an alternative method that will enable researchers to produce a stable domesticated population of the species by shortening the fruiting period and capturing the desired traits. This will guarantee income of the rural population using these improved planting materials, while decreasing pressure on a valuable natural resource that is currently harvested in some of its natural range.

By rooting cuttings on your nursery you do not need to rely on the parent plant producing seed and you can overcome many of the problems of seeds germination. Vegetative cuttings mean that you can select the exact plant that is suitable for your needs i.e. the individual plant that you know as female rather than leaving this to chance with a random selection of seedlings.

The most crucial step in vegetative propagation of *Allanblackia* species is the selection of the superior material and mother blocks site. The cutting of the trees should take place at least 6 months before the planned collection of the cuttings. Select well performing female adult trees for cuttings free from pests and disease and known for big fruit, many seeded fruit and good yield. Selected trees should have a diameter of 20 to 50 cm and be on a partially open site (20-50% shade), that receives sunlight laterally (mornings and afternoon).

4.1.1.1. Preparing for sprouting shoots from stump or established mother blocks

Cut down the tree at a stump height of 50 to 75 cm high with one side slanting during the rainy season especially during March to May season. Paint the stool to reduce rotting. Leave it to resprout and for the next 4 to 9 months depending on the season it was cut before collecting the propagules materials.

When using conventional cuttings for planting, coppiced stumps from selected mother trees or established mother blocks of specified characters should be identified, three to six months before cuttings are taken depending on weather conditions. Fertilizer can be applied to the mother blocks to speedup the resprouting.

Cut tree being painted to reduce fungal infection in Nigeria

Well coppiced stump in Ghana

Coppices ready for collection

Harvesting

Coppiced stump, Nigeria

4.1.1.2. Selection of coppices/mother bushes

Long vigorous coppices about 6 mm thick at the base are collected from nucleus bushes or coppiced stumps. If possible, collect thick very vigorous shoots or twigs, before they become too woody. The variables are: tree felling time of mother trees, rate of growth of coppicing stumps, and time chosen for taking cuttings. Good timing balances the variable as required. Undertaking effective selection based on observations made in natural stands is not a straightforward process.

- ⇒ Select vigorously stump bushes for cuttings.
- ⇒ Avoid the woody, brownish and the very succulent parts of the branch

Temporary small poly fabricated tents of the size 1m x1m x 1m are found to be most useful where the source of scions or cuttings is far from preparation area as it could be installed under the mother tree/ bushes. Moist sand layer is provided to provide green house condition. The time spent in cuttings or scions transportation is shortened, allowing for greater retention of turgidity of scions and better success.

4.1.1.3. Collecting and handling shoot cuttings

Shoots should be taken early in the morning, preferably in misty weather or just after rain. This will keep drying out to a minimum. Select or take the stems from coppices or mother blocks with a diameter of 0.4-0.6 cm. Wrap these stems in wet sacking or polythene bags and take to a shelter near the nursery or in the nursery where they are immediately watered. Cuttings should be made under shade and kept shaded at every stage there after. Remove the soft uppermost parts and any lower parts where bark is forming. If the cuttings are too soft they will be damage at planting and many of them will die. If they are too hard they will grow poorly leading to stunted growth or death.

- ⇒ open a polythene bag, moisten the inside and put in a label with the clone number, and also write it on one or two leaves with an indelible marker;
- ⇒ Collect shoot tips 8-12 cm long, preferably in the morning or evening. Cut the shoots from the stock plant with a sharp pair of secateurs or knife, and place them in the bag. Keep it closed and in the shade
- ⇒ as soon as a bag is completed, spray the shoots lightly, close it with a tie, and attach a second label with the clone number and estimated number of cuttings;
- ⇒ Take the bags to the propagation area as quickly as possible. Avoid piling up or throwing of bags or the shoots may be damaged. Reduce crushing and bumping of shoots by supporting the bags in separate boxes or with elastic cords.

Transferring harvested shoots into water basing

Soaking Materials ready for cutting, Cameroon

Preparing cuttings during a training session in Ghana

4.1.2 Using a non-mist propagator

4.1.2.1. Preparing the cuttings

The stems are tested by flexing between thumb and fingers: the soft portion at the top and rigid portion at the bottom are not suitable. Good cuttings come from the flexible middle portion. Cuttings should always be prepared under shade in a bucket with water and planted immediately. The cuts should be clean and sharp without any jagged ends.

Make a new clean-cut base to the cutting, using a very sharp knife or scalpel blade to remove wood that has been split or damaged by the secateurs, which might rot and to shorten cuttings that are too long. The Internode Cutting should be 3 to 4 cm long, top cut made immediately above the axillary bud in line with leaf, basal cut at about 90° at least 2.5 cm below the petiole of the mother leaf to avoid the rooting system to one-sided. The cuts should be clean and sharp without any jagged ends (e.g. just below a node).

4.1.2.2. Trimming the leaves

Large leaves may lead to more loss of water by the unrooted cutting. Trimming of leaves makes the cuttings easier to handle, take up less propagation space and be less likely to rot. The leaf area of these cuttings is reduced or trimmed by clipping off ½ to ¾ (25 to 50 cm²) of each leaf with a sharp pair of scissors.

To help ensure the success of your cuttings, strict hygiene practices must be followed, i.e. working surfaces and secateurs should be sterilised with a dilute solution of bleach or alcohol where possible.

Cutting the base of the cutting flat with a scalpel

Trimming leaves

4.1.2.3. Setting leafy cuttings

The rooting medium should be sterile, low in fertility, and well-drained to provide sufficient aeration. Mix common materials, such as sand-sawdust mixture (33% grit or fine gravel, 33% sharp sand and 33% old sawdust to make rooting media. At least 24 hours before planting cuttings, the beds should be watered properly.

For best result cutting should be planted in the morning or late in the evening when the weather is cool. Soil surface is pierced with a 5 cm thin dibber. The hole made should be a little shorter than the stem of the cutting. The direction of the hole should allow the leaf to stand nearly upright. Carefully insert the cuttings and avoid damaging the cut point, keeping the axillary buds and the petiole of the mother leaf at least 4-5 mm above the soil surface and the trimmed mother leaf in an upright position. They should be planted in the same direction. The soil near the cutting is compressed with finger tips to eliminate air.

Maintain the vertical orientation of the stem (do not insert the cuttings upside down). Make sure the buds are pointed up. Space cuttings just far enough apart to allow all leaves to receive sunlight.

After inserting the cuttings, water again using hand sprayer or Knapsack sprayer and close the cover. Put overhead shading to the propagation area. Shade excluding at least 25-40% of the day light is necessary at this stage. Increase the shading of the canopy the first week but reduce to standard 25-40% from the second week.

4.1.2.4. Care and maintaining the poly-propagators

⇒ Avoid direct sun and keep the medium moist until the cuttings have rooted.

⇒ keeping the propagator shut as much as possible;

⇒ spray the cuttings with fine droplets of water weekly, and whenever the propagator is opened.

Rooting will be improved if the cuttings are misted on a regular basis especially in late afternoon and early morning especially when the weather is hot and dry.

⇒ potting up cuttings early or late in the day, or during misty weather;

⇒ clean the outside of the polythene sheet each week with water and a soft cloth, to avoid scratching it.

⇒ check the water level each week, and add more if needed, down the plastic pipe;

⇒ patch or mend any holes or tears in the polythene sheet with a small piece of sticky tape, or polythene sheet glued on.

⇒ Cuttings take 10 weeks or longer to root.

⇒ Clean the inside in the same way, preferably just before putting in a new batch of cuttings;

⇒ Harden-off the cuttings by reducing watering and gradually remove shade.

⇒ Tend them in the nursery for sometime before transplanting them to the field.

Setting the cuttings in the propagator

Set cuttings with good spacing and orientation

Taking care of propagator by removing condensation

Cleaning the sheet to allow light in

If you see any signs of wilting, and the soil is still moist, don't water! Immediately cover such plants with extra shade, move them to a more humid place or even put them back inside a weaning chamber or poly-propagator. The problem might be that the new plant is losing more water from its leaves than it can replace from its still limited root system.

4.1.3 Low tunneling (raising seedlings under polythene tents) method

4.1.3.1. Single node cutting

The good material is made into individual cuttings of a single leaf with an axillary bud and 3 to 4 cm of stem below the leaf. Cut off any extra length of stem if necessary. The top cut should be just above the axillary bud and slanting away from it. The leaf area of these cuttings is reduced by clipping off half of each leaf. The cuttings should be put in water as they are prepared to allow a continuous xylem flow.

Harvested cuttings

Prepared single node cuttings

4.1.3.2. Setting of the cuttings

Pots should be watered to field capacity two days before cuttings are planted. Cuttings should be placed in a solution of fungicide at a rate of 30-50g of fungicide powder in 15-20L of water for 30 to 60 minutes before planting. Too many cuttings should not be placed in a container otherwise the top ones will not be in water and the bottom ones will be pressed so hard that the leaves may be damaged. Cuttings should be inserted into the soil leaving 12 mm of stem above the soil, making sure the leaf does not touch the substrate.

Stacking

A complete stacked bed awaiting cutting setting

Plant one cutting in one pot and make sure that there is minimum overlapping of leaves and the axillary bud is not obstructed. All leaves should point in one direction along the bed, ensuring that the leaf does not touch the soil. Cuttings with damaged leaves should be rejected as they generally grow slowly and are prone to fungal infection through the wounds. At the end, light watering is needed to seal air spaces around the cutting.

4.1.3.3. Polythene sealing

After planting, a clear polythene sheet is placed and stretch over the semicircular frame with hoops that are 30 –40 cm at the middle above the sleeve soil level. The sheet is then sealed into the soil around the bedto exclude any exchange of air. To help in stretching the polythene sheet and sealing it, an extra length and width are usually allowed for in the plan. Condensation should occur inside the polythene tents within 24 hours after planting.

Setting cuttings

Set cuttings ready for covering

Completely covered low tunneling

4.1.3.4. Management in the nursery

⇒ Tap the polythene sheet with fingers every morning to drop the dew and allow the light through

⇒ Watering should be done whenever condensation decrease inside the polythene sheet.

⇒ Fungal infections are controlled by periodic watering beds with diluted fungicides mixtures such as that used at planting cuttings. Common fungicides are Dethane, Bravol, ivory and Ridomil.

⇒ Any operation involving opening of the tent should last for a maximum of 30 minutes.

⇒ Regulate shade depending on the weather (25-40% shade).

⇒ Rooting should be visible from drainage holes after 3-4 months after setting. **Note: sprouting does not guarantee rooted cutting.**

⇒ Patch or mend any holes or tears in the polythene sheet with a small piece of sticky tape, or polythene sheet glued on.

Rooting chamber with condensation

Seedling under chamber

The polythene cover serves the following functions: it prevents loss of soil moisture hence preserves high atmospheric humidity; it increases the air temperature; saves labour cost in watering; protects cuttings from rain and wind damage and; keeps the temperature range inside the polythene cover low

Lack of condensation may be due to insufficient water supply, holes in the polythene tent, improperly tucked polythene and excessive shade.

4.1.3.5. Hardening off plants

Hardening off is done to introduce plants to the external environment similar to field conditions, when the majority of cuttings have rooted. Normally it should be done four to six months after planting in the nursery. The operation is carried out in two stages starting with gradual removal of polythene tent and thinning of shading materials above and on the sides, and reduction of water application (watering regime).

4.1.3.6. Sorting and Grading

Sorting is a practice done to separate weak from strong plants. Plants will require grading after having had the polythene sheet removed completely. Grading is done by placing large plants to one side of the bed and small plants to the other. This allows the small ones to develop without excessive competition for light from the large ones and also, allows the larger plants to perform or grow uniformly in the field.

Reduce the watering and shading 1-2 months before field planting. Growing clones to a larger size before transplanting to a permanent location (for planting) will increase the chances for survival.

4.1.3.7. The Rooting bed (callus beds)

If the sleeves or polythene bags are not available, rooting beds can be used. An ordinary well shaded bed, the top 15 cm of medium loam, well worked but firm and of average fertility. Cuttings are set at 5 cm X 6 cm spacing. When roots have developed (8-12 weeks), the rooted cutting is transferred to a sleeve. Where cuttings are set direct into sleeves, rooting beds are a reserve for replacing mortalities.

A clonal callused cutting being lifted for transplanting into polybags: Where indirect setting is used, cuttings should be rooted before transfer to sleeve.

In **East Usambara**, where the temperature is low at night it is advisable you place the cuttings into the weaning chamber for a period of 2-4 months before transferring them out to the net shade (40% shade). When watering every two weeks you can apply NPKs fertilizer at the rate of 10g in 10litres (1 tablespoon on 1 watering can). Water the plants thoroughly to remove any excess fertilizer.

4.1.4. Post rooting operations

Since rooting is done under controlled conditions very different from growing conditions, rooted cuttings or shoots must be hardened off or acclimatized first before being exposed to outside conditions.

4.1.4.1. Removal of polythene

This involves loosening the polythene sheeting at both ends of the bed and leaving the polythene sheet loose on the ground for a week. One week later the polythene is rolled up at both ends and left that way for a week so that air may circulate. Then the polythene is rolled up 30 cm at each end, a week later it is rolled up 120 cm at each end. This weekly opening continues to increase by 1.2m per week until the whole bed is uncovered. The polythene sheeting is then washed, dried and stored as before. Care should be taken not to allow the soil in the sleeves to dry up during the hardening off period.

There could be many variations of hardening off plants, but whatever method is used, the hardening off should be gradual to give the young plants time to acclimatize themselves to their new conditions and be able to withstand any adverse weather which may set in later. After unsealing the tents, water requirements will increase. Infrequent, heavy watering is better than little and often, but over watering must be avoided.

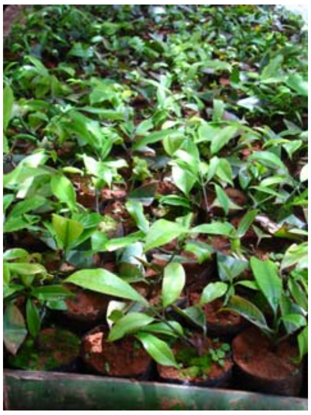
Rooted cuttings require a lot of attention up to the time they are transplanted to the field. The problems generally encountered at this stage include poor and uneven growth, sometime with some cuttings looking very stunted with pale yellow leaves, scorching, shoot die back and wilting of plants.

4.1.4.2. Fertilizer application

Fertilizer application can be used to boost shoot growth but it is always essential to fully dissolve the fertilizer making a solution that has no danger of scorching plants. For pots containing fertile topsoil in the lower part of the sleeve, fertilizer application may start immediately after the cuttings have been hardened off or preferably before the rooted plants look yellow.

In either case, Sulphate of Ammonia (21%N) is applied by dissolving 500g of SA mixed in 200L of water and 10L of solution administered in $1M^2$ of a bed. One application per week over three weeks would be adequate to promote shoot growth. Later application can be replaced altered with NPK 25:5:5 at 1gN/M2. 4 gm dissolved in 1.3L of water monthly. In both applications an immediate application of clean water should follow, to wash the fertilizer solution off the leaves of the young plants to avoid scorching.

Note: The success rate depends on the country and method used. In Cameroon, 70% has been reported when using non-mist propagators. In Tanzania, 40% has been reported when using low tunnelling and depending when the setting of cutting was done.



Rooting cuttings

Healthy cuttings after 4 months

Healthy rooted cutting, Tanzania

Flowering sapling from cuttings in Cameroon

4.2: Marcoting/Air layering

⇒ Select a healthy; clean branch 1-5 cm in diameter from an adult *Allanblackia* tree.

⇒ Girdle the branch by removing the bark all around that branch in a band 4 to 5 cm wide. Remove any fibres from the girdle to cut away the phloem completely.

Girdle the bark with a knife (see description overleaf)

Putting the media in place

Tie both end tightly with rubber band or sisal twine

⇒ Use rooting media that is soft and holds moisture, like decomposed sawdust, moss or compost.

⇒ Water the media sufficiently.

⇒ Wrap the girdled branch in a transparent polythene sheet filled with rooting media. Tie the ends directly on the branch. Check twice a week.

⇒ Roots should develop under the transparent polythene sheet.

⇒ Cut the branch below the polythene cover, leaving it in place.

⇒ Immediately after cutting, transplant stems into containers. Cut the branch into 40 cm long stems from the girdled part. Remove the polythene cover. Be careful not to damage the tender roots. Plant the stems so that the roots are sufficiently covered. Use only fertile, clean soil media.

⇒ Place the planted marcots into the weaning chamber to facilitate the establishment of the plant.

⇒ The success rate of marcotting is 40-80%. Monkeys and locals people destroys the set ups if isolated.

Harvested marcots

Rooted marcot ready for transplant

4.3: Grafting

Grafting may be an important procedure in the future for producing monoecious plants in AB (that is, grafting female scions into male trees, or *vice versa*, in order to produce individuals with both male and female flowers) that are capable of self-pollination, obviating the need for separate male individuals that occupy 'unproductive' space on farmland.

4.3.1. Collecting, handling and setting scions

From the selected superior coppiced stumps or mother blocks already established.

⇒ Collect suitable coppices for scions (cuttings) same diameter as rootstock

⇒ Collect cuttings that are 10 to 20 cm long, with 4 to 6 bud eyes

⇒ Keep scions (cuttings) in moist black poly-bag, base downwards to avoid desiccation.

4.3.2. Preparing the rootstock

Seedling ready to graft in the nursery

Grafting of seedlings

⇒ Take a length of rootstock from the stumps or mother blocks you have prepared well—one with a single stem, in good shape and well watered.

⇒ Select the best position at a height of approximately 25 cm from the bottom and make slice the veneer cut of the rootstock; cutting down, towards the bottom of the rootstock making sure you do

Grafted seedling in-situ, Tanzania

Cover the scion with polybag to reduce moisture loss

Grafted seedling in a weaning chamber, Tanzania not cut veneer off. The cut must be a smooth cut and not split the rootstock

⇒ Compare with the diameters of your scions. The diameters of the scion and rootstock must match.

4.3.3. Preparing the scion

The side-tongue procedure was more successful than side veneer or whip and tongue approaches.

⇒ Remove any end of a scion that is dry.

⇒ Make two cuts to get a wedge at the bottom of the scion that fits into the side veneer of the rootstock.

⇒ Make smooth, straight cuts, trying to move your hands smoothly, without tension.

4.3.4. Insert the scion into the rootstock

⇒ Insert the scion smoothly into the side veneer.

⇒ Do not press too strongly. Do not touch the surface of the cut in the scion or the veneer cut of the rootstock.

⇒ Ensure that the bark of the scion and the rootstock match properly or touch at one end.

Note: Temporary small fabricated poly tents of the size 1m x1m x 1m are found to be most useful as it could be installed under the mother block or tree especially where the source of the materials is far from the preparation/nursery area. Moist sand layer is provided to provide green house condition. The time spent in cuttings or scion transportation is shortened, allowing for greater retention of turgidity of materials and better success.

Grafted seedling in the nursery, Ghana

Mass grafting in Rural Resource Centre (RRC), Ghana

To protect the grafting union from water, disease and drying, tie it with a thin polythene strip to hold them together.

⇒ Cover the scion and grafting union with a transparent polythene bag to minimize water loss.

⇒ Do not expose the grafts to direct sunlight or strong wind. Construct a shade roof if necessary.

⇒ Note: Success rate for grafted seedlings should be 30 to 70% depending on the site of grafting and stage there are grafted.

Note: In **East Usambara**, low cost poly tents made of polythene sheets (acts as a green house) are required for weaning grafted seedlings of Allanblackia.

Flowering grafted seedling in the nursery in Ghana after 14 months

Flowering grafted seedling in Cameroon planted in 2006

4.4. Seedling management in the nursery

4.4.1. Normal nursery routine

Water seedlings regularly, early in the morning or late in the evening. If diseases or pest are detected those seedlings should be removed from that rot and treated as required immediately to avoid further infection or spread.

4.4.2. Hardening off

Plants must be hardened off a few weeks before transplanting to the field. This is done by reducing watering and gradual thinning the overall shade and then exposing the plants to full sunlight before they are moved to the field. This is very important otherwise plants will get sun scorch and die, soon after transplanting.

It might be necessary to regrade prior to final period of hardening off as this will prevent over shading by plant and subject them to better exposure to sunlight. The aim is to have plants completely hardened about 2 to 3 months before they are transplanted in the field.

4.4.3. Weed Control

Hand weeding from the beds as well as sleeve surfaces should be carried out as a routine practice. Mossy growth as and when noticed should be scraped using a small piece of stick or dibble. Impeded drainage and over-watering are two main causes for growth of moss. Therefore, improvement of drainage should receive priority.

4.4.4. Pests and diseases

Various insects have been reported to affect coppices. Rodents can cause considerable damage especially on seed beds and storage. Fungal infection is an important disease when raising the cuttings. Aphids, bacteria and virus are slowly seen infecting seedlings in the nursery. Treat the infection as necessary.

4.4.5. Transplant to field

Transplant to the field after one to two year depending on how you were weaning them in the nursery. The ground to land for planting should be prepared early enough before rains. Planting should be done in the rainy season. Spacing should be determined by the size of the land to be planted.

4.5.0: How to establish and manage a clonal mother blocks

A clonal bank or mother block or stockplants is a collection of selected asexually propagated clones or plants which are managed for breeding work. A mother block/bush is a plant specially managed so as to produce shoots or suckers for cuttings or grafting which will be grown in a nursery to develop new plants. Therefore a multiplication plot is that plot comprising of mother blocks/bushes. By establishing stockplants near the propagation area, a nurseryman will be able to supply enough and the right type of material needed in other processes. Seedlings raised from cuttings are used to establish of clonal banks for ex-situ gene conservation. After a clonal test the best performer clones are retained (the "bad" ones are removed), then pollarded to induce the production of juvenile shoots which are then vegetatively mass multiplied by rooting of cuttings. These rooted cuttings are used as propagules for clonal development.

Great variability exists among clones in terms of growth and vigour (resistance against pests and diseases). The decision, on how many clones to be planted in the bank is reached after considering also the shoot productive capability of the clone, the success of rooting cuttings (it varies among clones), the survival rate/ percent of the rooted cuttings in the field, and the annual planting target area.

4.5.1. Mother block or stockplants are required for

- ⇒ producing many shoots quickly in order to get plenty of cuttings.
- ⇒ to reduce the need to travel.
- ⇒ to have them near so that cuttings can be collected and set on the same day.
- ⇒ for easier protection.
- ⇒ planning and management of operations is easier

4.5.2. How to establish a mother block

- ⇒ From the selected coppiced plus trees from a natural stand use either grafted or rooted seedlings, whichever is most effective to obtain high success of establishment. Marcotting, if equally effective could be used to vegetatively reproduce the mother tree (ortet). The number of seedlings (ramets) in each clone should not be less than 20.
- ⇒ Harden the seedlings in the nursery for sufficient duration to allow them to fully develop before planting in the field.
- ⇒ Plant clones in rows or lines, placing identification tag on a one-metre tall stake, indicating the clone code number (stump). Then put stakes at each planting spot within a line and dig planting holes. The distance between lines/clones and seedlings of the same clone (within line) is 4 metres.
- ⇒ Plant the clones during the onset of the rainy season. Do not mix clones but plant them according to the stump or plus tree number for identification. All seedlings belonging to a clone must be planted on one line. Sketch the lay-out on a map of the clone bank and ensure that the locations of the clones are properly recorded/indicated for future references.

4.5.3. Selecting the superior clone in a bank

The objective of the breeding programme is to create new clones with a well-developed root system ensuring a survival rate in the field; better than average pest and disease resistance; and ability to reproduce faster.

Since the clones are planted in lines, it is possible to compare them with ease in regard to their growth behavior, stem form and resistance or susceptibility to insects and diseases. This constitutes a clonal test which could run for some years. Then based on the result of this test, those clones (including seedlings) which were found poor performers (poor rooters and growth performing) are removed from the clone bank. Select only those clones which have produced progenies with the best quality and the highest yields. These inferior clones, however, could be replaced by new selected clones.

4.5.4. Multiplication of juvenile shoots

The blocks should be pollarded to induce the production of more juvenile shoots. Then, cuttings from these juvenile shoots are rooted using standardized propagation procedures to mass multiply them. Properly graded rooted cuttings are then utilized for the development of clonal materials.

4.5.5. Clonal Multiplication Area

To ensure the production of juvenile materials for mass multiplication is to establish a clonal multiplication area near the propagation facilities and nursery. Much of the AB breeding work focuses on production of sufficient planting material rather than breeding for high yield and quality. To obtain improved clones from high-performance clones, elite clones should be established, surrounded by a guard row of same clones.

Coppices are harvested from this multiplication area, transformed into stem cuttings for rooting in the preferred standard propagation method. The ratio of clonal multiplication area to area of planting is 1:100 i.e. to plant 100 hectares you need one hectare of clonal multiplication area.

4.5.6. Maintenance of the clonal bank

The ultimate success in the nursery is very largely dependent on the standard of the cuttings taken which in turn depend on the management of the multiplication plot. It is therefore well worth taking the measures to see that source bushes are correctly managed. Mother plants which produce cuttings which fail to root or which give low rooting percentage under optimal nursery conditions should be discarded irrespective of other of desirable characteristics as it would be difficult to establish them in the field.

Regular pruning of the bushes is required to remove old branches and also to induce continuous production of juvenile shoots. Apply commercial fertilizer rich in nitrogen or organic fertilizer to the clones to encourage substantial shoots development after pruning. This practice will induce the production of more vegetative parts in addition to maintaining the general health of the clones. The prospects for further advancement in creating high productive plants have been emphasized on improved methods of selection, hybridization and clonal propagation.

Glossary of terms

Additive (Fertilizer) - A substance which is added to fertilizer to improve its chemical or physical condition.

Air Layering - It is a method (asexual) of plant propagation by layering wherein roots are formed on the aerial part of a plant after the stem gets injured or girdled or slit at an angle. This portion is then kept in a moist rooting medium. It is commonly used for propagating a number of tropical and subtropical trees and shrubs.

Artificial regeneration: establishing a new forest by planting seedlings or by direct seeding (as opposed to natural regeneration).

Axillary bud: A bud found in the angle between leaf and stem or at the axil of a leaf (synonymous with lateral bud).

Bareroot seedling: stock whose roots are exposed at the time of planting (as opposed to container or plug seedlings). Seedlings are grown in nursery seedbeds and lifted from the soil in which they are grown to be planted in the field.

Canopy: the forest cover of branches and foliage formed by tree crowns

Clonal Selection - Refers a method of selection of desirable clones from the mixed population of a vegetatively propagated crop.

Clone - A group of plants all having an identical genetical make up, being the descendants of a single parent (the mother bush). In plant breeding a clonal stock of plants can be vegetatively raised by taking cuttings from a single parent plant.

Coppice (coppicing): the tendency of certain tree and brush species (such as red alder and bigleaf maple) to produce a large number of shoots when a single or few stems are mechanically removed but the root system left intact.

Cultivar - A variety of a cultivated plant.

Cutting - A cut section of material removed from a living plant which, when placed in a suitable rooting medium, will produce roots and give rise to a new plant.

Dioecious - A term applied to plants having the male and female flowers borne on different individual plants of the species

Elite tree - A tree that has been shown by progeny testing to produce superior offspring

Endemic species: a species whose natural occurrence is confined to a certain region and whose distribution is relatively limited.

Evergreen: never entirely without green foliage, leaves persisting until a new set has appeared.

Fungicide - A chemical used to destroy fungi and thus control fungal diseases.

Gene bank - A collection of germplasm (seeds, pollen, whole plants, extracted DNA) collected and maintained so as to sample as much as possible of the genetic variability in a population

Genetically improved seed and/or vegetative propagules: seed or propagule that originate from a tree breeding program and that have been specifically designed to improve some attribute of seeds, seedlings, or vegetative propagules selection.

Graft - A shoot of a desired plant variety (a scion) bearing a bud, joined on to the stem of another variety (the stock) with a weaker or stronger rooting system, as required, so as to develop into a whole plant, usually a tree or shrub, of the same variety as the scion. Grafting is a common method of propagation.

Insecticide: A substance used for killing insects

Juvenile Form - Young plant that is having leaves and other feature different from those of a mature plant of the same species.

Mother bush: A bush or stump coppice selected for its desirable characteristics which has been multiplied by vegetative propagation. The plants so produced form a clone to produce shoots for cutting.

Muriate of Potash - A fertilizer containing at least 60% potassium chloride, and as much as 3% sodium chloride or common salt. Available as a straight granular fertilizer but mostly incorporated in compound fertilizers.

Mycorrhiza: a rootlet of a higher plant modified through integral association with a fungus to form a constant structure which differs from either component but is attached to the root system and functions somewhat as a rootlet. It is usually considered to be beneficial to the associated plant.

Nursery - Beds where seedings are grown for transplanting to the field.

Offspring; Progeny - (both same in plural) New individual organisms that result from the process of sexual or asexual reproduction.

Ortet- The original plant from which a clone is started through rooted cuttings, grafting, or tissue culture, or other means of vegetative propagation. The original plus tree used to start a grafted clone for inclusion in a seed orchard is the ortet.

pH: The standard measure of acidity or alkalinity. It is the negative logarithm of the hydrogen ion concentration. The neutral point is at a value of 7. Higher values are of alkaline while lower are of acidic.

Pesticide: A substance used for destroying insects or other organisms harmful to cultivated plants or to animals

Plus tree- A phenotypically superior but untested tree.

Propagation - (to propagate) The multiplication of plants by numerous types of vegetative material; an ancient practise dating from the drawn of agriculture carried out in a nursery or directly in the field (vegetative propagation), and now in vitro culture (micropropagation). The term is used in horticulture to mean the artificial multiplication of plants by 'vegetative means, including the taking of cuttings, Layering, Budding, and grafting etc.

Propagule - a part of plant (usually referred to a vegetative organ) that becomes detached from the rest and act for the dispersal of the species and from which a new individual may develop plant by asexual or sexual reproduction (for example a bud, or other body offshoot capable of independent growth.)

Protocol - (Gr.protokollon, first leaf gluded to a manuscript and describing the contents) The step-by-step experiments proposed to describe or solve a scientific problem, or the defined steps of a specific procedure.

Pruning: The removal of vegetative material of a plant at long interval

Ramet- A vegetatively reproduced copy of a plant. Each ramet will have almost precisely the same genotype as the original parent tree, known as the ortet.

Roguing - Removal or cutting of individual plant from the seed plot which deviate insignificant manner from the plants of the variety being multiplied. This is a step in the maintenance of purity in an established variety.

Rootstock - The trunk or root material to which buds or scions are inserted in grafting.

Scion - The twig or bud to be grafted onto another plant, the root stock, in a budding or grafting operation.

Seed - A reproductive structure of flowering plants. It develops from a fertilized ovule and comprises an embryo and a food reserve contained in a protective coat or testa.

Seedling - A young plant, grown from seed as distinct from one grown from a cutting or by a graft.
Selection - The basis of plant breeding in which individuals are selected for breeding on the basis of specific desired characteristic or qualities.

Sub soil: The layer of soil under the topsoil which contains little organic matter

Tending: any operation carried out for the benefit of a forest crop or an individual there of, at any stage of its life. It includes operations both on the crop itself and on competing vegetation but not site preparation or regeneration cuttings

Topsoil: The upper or top layer of soil rich in organic matter

Vegetative material: plant parts or tissues used to produce vegetative propagules through asexual means.

Vegetative propagation (VP): Growing new plants from a piece of an old one by the detachment of a part of the plant, thereby perpetuating the exact character of the mother plant. In general terms VP includes budding, grafting and tissue culture.

Vegetative propagules: plants produced through asexual means.

Weaning - Gradually accustoming potted cuttings to grow under ordinary nursery conditions.

Wildling: a seedling naturally reproduced outside of a nursery, used in reforestation.

Further reading

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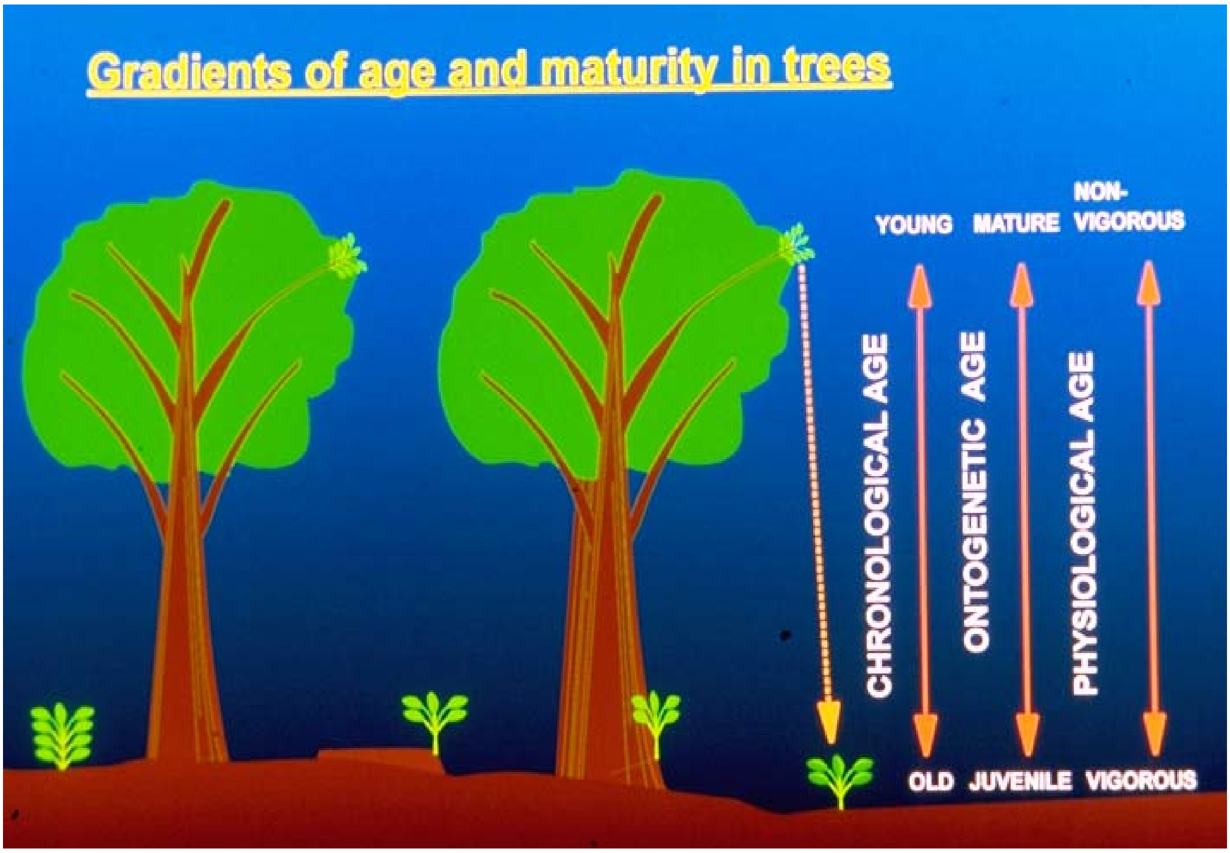
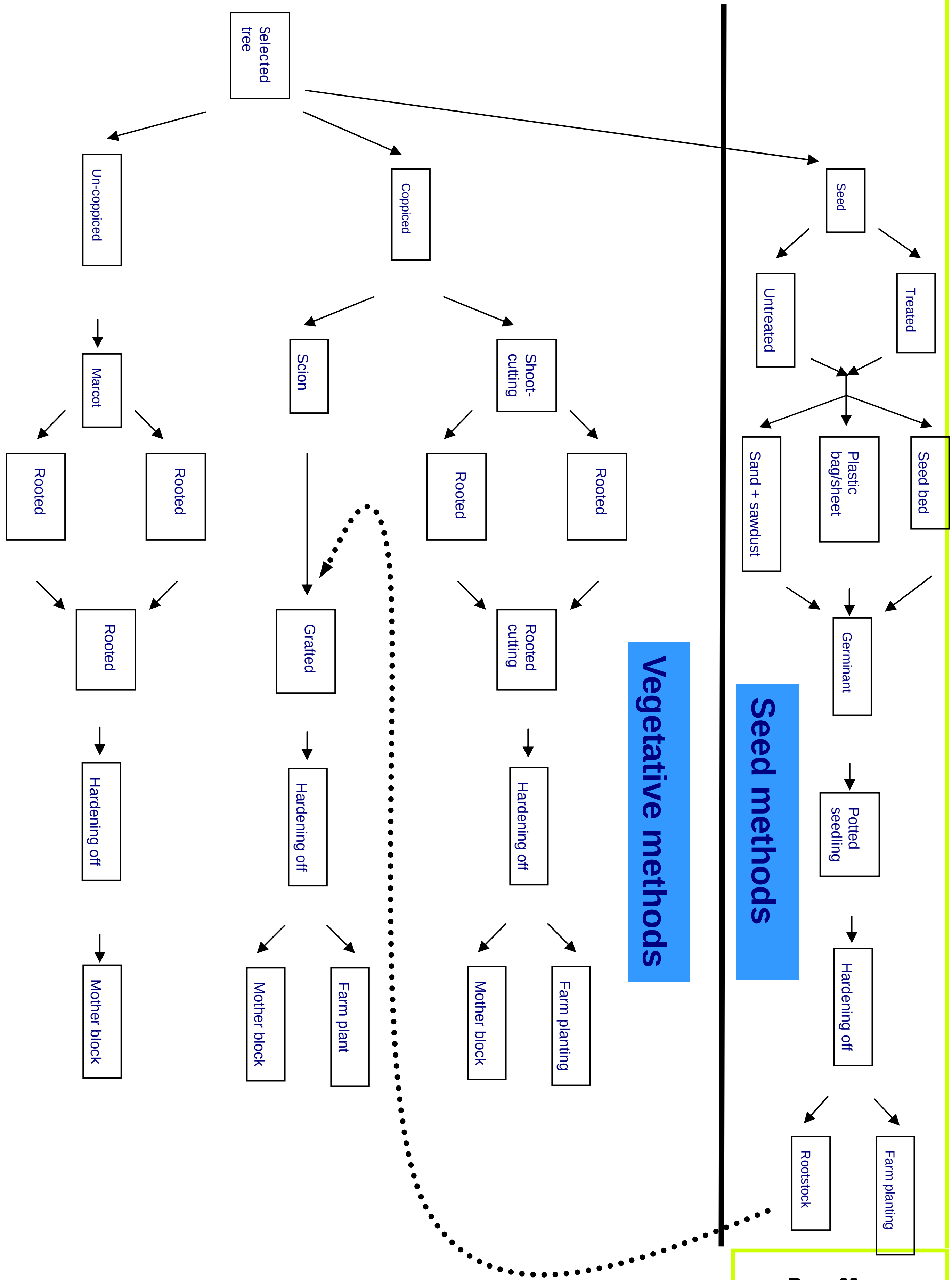
Appendix 1:Based on the cuttings of trees and resprouting of coppices on stumps, the vigor of the propagules produced can be explained as shown in the diagram below:

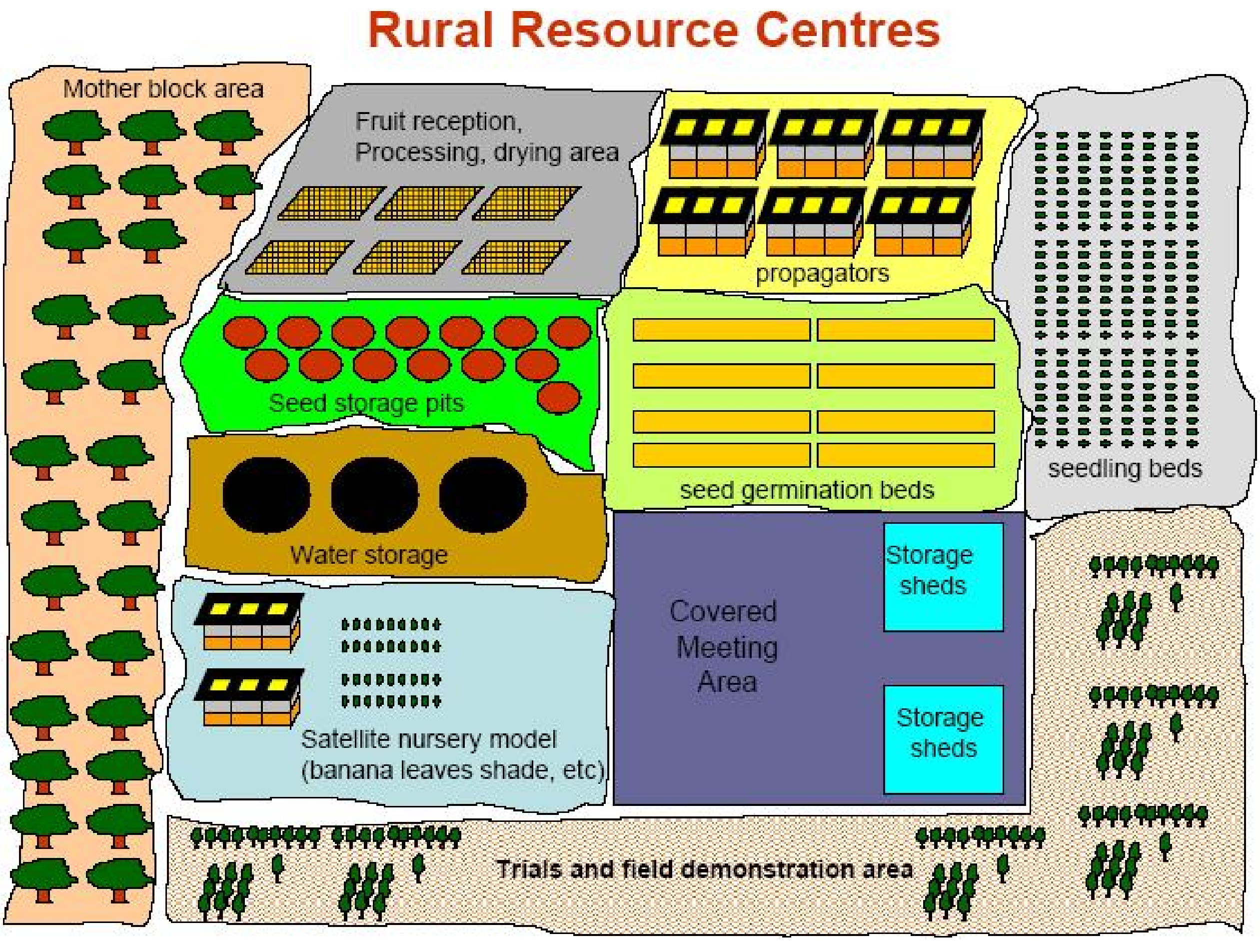


Below is a coppice with juvenile materials that are vigorous

Appendix 2. Diagram showing different propagation methods



Appendix 3: A model RRC



Appendix 4: A Mother block model

Breeding is a lengthy process and uncertain one, it needs high level of tolerance and patience before a breeder can achieve the intended planned objectives. Vegetative clones are generally superior to plants raised from seeds; at the same time you are sure of the sex of the seedling raised. Selection is applied in identifying promising plants from the existing populations as sources for production of improved clonal varieties or hybrids. In the nursery, seedlings are assessed based on their vigor, uniformity, and quality to obtain superior clones. Only clones that look to be promising in terms of good nursery material should be retained.

Mother tree selection criteria:

The selection process in any crop/tree is an art. Selected at least 25 plus trees (superior mother trees), from a natural stand. Care should be taken when selecting of individual trees; select trees that are on 10 to 50% canopy with lateral lighting. The canopy is an influencing factor in the flushing of coppices in this species. Open areas and very dense canopy delays the coppicing in this species. The preferred trees should be on-farm ones rather than in the forest. This is because tillage around the stump and clearing increases the sprouting. Another criterion is trees far from the homesteads are not suitable as wild animals' feeds on the coppices. This affects the regenerative characteristics of stump which further promotes pathogen infections and sometime death.

Selection in Allanblackia trees for useful breeding objectives should been based on the following criteria;

⇒ **Visual selection**- The key objective for selection remains to develop cultivars which will give maximum economic returns irrespective of variation in climate, soil, cultural practices, diseases and insect pest incidences. Characteristics such as tree stature, fruit size and number of seeds are most commonly used in selecting mother trees for vegetatively propagated clones. Also, for identifying progenitors for breeding high yielding seedling oil quality, although, selecting of above average plants may be difficult due to rare existence of outstanding trees in the populations. Visual selection based on vigor may also be too subjective. The vigor can also be judged on cuttings rooting ability and seedlings growth.

⇒ **Ability to coppice and shoot numbers:** The density of flushing points on the coppices is considered useful criteria for selecting potentially high yielding clones; this may be useful criteria for projecting yield potential of mother tree. In Allanblackia coppice bush, shoot size together with flushing capacity should be considered as indicator of good cropping capacity.

Allanblackia trees are especially influenced by timing; cut during the starting of the rain. After a certain age, often years, trees may even have difficulty producing cutting viable to produce roots. Select trees, that are not too old nor to young. Cut down the mother trees to a height of 0.5 to o.75 metres during the start of the rainy season. Paint the stumps to reduce rotting. Let the stump to coppice for the next 3 to 6 months depending on the species and the location of the stump. Let the coppices grow to a about a metre before starting to harvest.

Selection of the best coppiced stumps

From the coppiced stumps, select the largest shoots for cuttings making sure you select the lignin part of shoot but with the flexible characteristics. There may be a 'best time' to take cuttings from the plant; during early in the morning or late in the evening. Discard any diseased shoots. Do not cut the shoots near the base when harvesting; leave at least 20 cm of the base. For better and continuous harvesting select some shoots leaving others to facilitate photosynthesis and further sprouting.

The development of highly productive clones depends on selection of good flushing behavior of individual stump. Selection indices include;

⇒ Rate of coppicing after tree cutting and recovery rate harvesting
⇒ Branching habit and size of flush shoot.
⇒ Resistance to insect pests, pathogens and environmental stresses.
⇒ Growth habit of the coppices and seedlings in the nursery
⇒ Test for clonal adaptability to various environments
⇒ Clones which do not meet set conditions are outright rejected

Transfer this to the nursery under in a moist black polythene bag. If you are moving the shoots fur from the harvesting site, make sure you wet them enough and transport them at night to avoid desiccation. Make sure if not planted that day, store the bag under glasshouse condition. Prepare the cuttings under suitable conditions as described in Chapter 4. To prevent the cuttings from dehydrating through the leaves and stems the cuttings are often propagated under non-mist propagators or tunnels covered with plastic.

Note: If tree canopy shoots are used, they tend to take longer before dropping leaves and rooting. Sometimes these cuttings from tree canopy take 6 months or longer before rooting. These should be avoided as explained in appendix 1 diagram.

Rooting conditions and duration in the nursery

Depending on the country, select the best method of rooting method preferred. In Tanzania low tunneling method is preferred to root the cuttings. In Cameroon, Ghana and Nigeria use of non-mist propagators to root cuttings is preferred. Some cutting from the same stock plant may root while others may not. Rooting of cuttings is affected by many variables. A few weeks difference in taking of cuttings may produce success or failure due to different rooting ability at different times of the year.

When rooted, transplant the ramets to polybags if using non-mist propagator. Keep the seedlings under cool conditions for 3-6 months; in Tanzania a green house is required initially (3 months). Select and grade the seedlings removing the diseased and week ones from the vigorous and healthy lot. After 3-6 month remove the seedlings from the green house or shade net (where available) to the normal swaziland beds. The seedlings should be about 15-30 cm long. Select the best seedlings from this lot (if they were in small polybags; transfer them to bigger ones) and add forest soils to make sure they have enough Mycorrhizal. This process boosts the growth and the healthy of the seedling. After 12 months, start preparing for the ground for planting. Harden the seedlings in the nursery for sufficient duration to allow them to fully develop before planting in the field.

Ground preparation

Prepare the land/planting site 3 months before the normal transplant of the seedlings to the field. This is to allow good soils aeration and moisture absorption. Plant the clones during the onset of the rainy season; in Tanzania, March to May is the best time for planting. The land should be well prepared to ease the planting and tillage once the seedlings are planted. Since Allanblackia is shade tolerant in seedling stage it is advisable to provide shade. This should be planted earlier before the clones are planted. The rows and shading plant- shading plant in a row should be 4 metres. In case of Tanzania, bananas are planted as shade plants.

How to plant bananas: Prepare the ground and dig holes which are about 1 to 2 metre deeps. Gather the weeds from the field and add to the holes. Add organic manure before planting the bananas. Leave the crater in the hole to hold water after planting the bananas.

Design of the mother blocks

Mother plants which produce cuttings which fail to root or which give low rooting percentage under optimal nursery conditions should be discarded irrespective of other of desirable characteristics as it would be difficult to establish them in the field. With regards to evaluation of clones on quality, the complication arises due to fact that the relationship between quality and morphology is too subjective. Successful clonal selection is possible if a strong correlation exists between mother trees and clonal derivatives. The propagation should focus only to clones with quality attributes and anticipated high potential fruit yield. Selected clones must be those with attributes that vary as little as possible within a clonal population. It also, offers chance to effectively exploit the hybrid vigor provided the selection of mother tree is accurate enough.

Only clone that have successfully passed the preceding tests are included at this stage. Plant clones in rows or lines, placing identification tag on a one-metre tall stake, indicating the clone code number (stump). Then put stakes at each planting spot within a line and dig planting holes. These lines should be between the banana lines in case of Tanzania. The distance between lines/clones and seedlings of the same clone (within line) is 4 metres. All seedlings belonging to a clone must be planted succeeding one another on one line. If land is small or seedlings are not many replicate clones in the lines (1 seedling per line). A minimum of 30 to 50 mother trees is required to have a good diverse genetic base. The clonal mother blocks should be surrounded by a guard row (buffer) of same clones. Inferior clones, however, could be replaced by new selected clones. Sketch the lay-out on a map of the clone bank and ensure that the locations of the clones are properly recorded/indicated for future references.

Criteria for good mother blocks

⇒ *Rooting abilities of planting materials:* Mother plants which produce cuttings which fail to root or which give low rooting percentage under optimal nursery conditions should be discarded irrespective of other desirable characteristics as it would be difficult to establish them both in the nursery and field. These traits are inherited to successful generations.

⇒ *Rate of recovery from pruning:* Clones with slow rate of recovery from harvesting the shoots tend to have low rooting and growth capacity, and hence they should be avoided as mother blocks.

⇒ *Tendency to produce shoots:* Plants which become dormant frequently are undesirable. Seedlings that flower and seed at the expense of vegetative growth become poor shoot yielders. Any clone with these characteristics should be avoided. This can also be contributed to poor management of mother blocks.

⇒ *Overall yield throughout the year:* Clones with high overall yield throughout the year are suitable germplasm sources. New clones intended to be grown in multiplication plots should be tested for their suitability to the local conditions. A clone selected in one site may grow poorly in another site.

Mother blocks should start yielding germplasm after 2 to 3 years if good management is practiced. They should be maintained at 1-2 metre high to ease the harvesting and management. Harvesting can be done 3-4 times in an year.

Trees management in the field

It is a common practice that the performance of the potential clones for quality is generally judged by reference to a standard clone or control clone. A clone which is unsuitable under good environment may be good performer under poor environment. A clonal seedling is more susceptible to herbivores and pathogens. Maximum care must be taken when making recommendation of suitable clone under specific environment. This implies that, locally adapted clones are ideal standards for each location i.e. the same clone should not be considered as standard for all locations.

Regular harvesting or pruning of the bushes is required to remove old branches and also to induce continuous production of juvenile shoots. Apply commercial fertilizer rich in nitrogen (NPK) or organic fertilizer to the clones to encourage substantial shoots development after pruning. This practice will induce the production of more vegetative parts in addition to maintaining the general health of the clones. To avoid frequent prune in a year, 1/3 of the plants in mother plot should be rested each 3 months without being harvested. Regular weeding is required in the mother block.

Appendix 5: A Mother block for *A. parviflora*

ESTABLISHMENT AND MANAGEMENT OF MOTHER BLOCKS ON *ALLANBLACKIA PARVIFLORA*

EXTENSION PAPER PRODUCED BY FORIG/ICRAF – GHANA, JUNE 2008

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What is mother block?

Mother blocks are technically stockplant orchard consisting of selected genotypes with desired characteristics and intensively managed purposefully for plentiful production of shoots for propagation. Shoot produced can be used for cuttings, grafting and layering.

Establishment of mother blocks

It is normally established close to the propagation nursery. Planting distance could be 3m x 3m and provided with light shade. Application of mulches may be beneficial for soil water conservation.

Management of mother blocks

Stocks are watered regularly to keep soil moisture content at field capacity. If possible, install irrigation system. Application of fertilizer is essential, possibly twice in a year to keep the stocks healthy for active growth of shoots

Harvesting of shoots

Shoots should be harvested at semi-hardwood stage. Shoot harvesting should be done in such a manner that the stocks become branchy and bushy (Figs. 1 & 2) for abundant production of shoots and/or cuttings per unit period of time.

Harvesting can be done 3 or 4 times in a year.

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Fig. 1. Harvesting to encourage serial multiplication of shoots and branches

Fig. 2. Bushy stock abundant production of cuttings

Advantages of mother blocks

- Avoidance of frequent travelling to the forest to harvest shoots
- Saves time and resources spent on harvesting shoots
- Shortens the transit time between shoot harvesting and setting of cuttings
- Improves rooting ability
- Does not need the services of tree climber
- Mother blocks can also serve as ex-situ gene banks

Above: *Allanblackia stulhmannii* seedlings, Tanzania

Left: *Allanblackia stulhmannii* fruit, Tanzania

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