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IMPORTANCE AND SCOPE OF SEED TECHNOLOGY AND NURSERY MANAGEMENT

IMPORTANCE AND SCOPE OF SEED TECHNOLOGY

Portia G. Lapitan

DEFINITION

- Seed technology refers to methods or techniques used to maintain the quality of seed from harvest till it is germinated.

IMPORTANCE

- The seed is the most practical, economical and commonly used planting material for propagation.
- The production of seedlings for planting in reforestation, agroforestry projects, forest plantation and other activities is largely dependent upon the germination of available seeds.
- The use of good quality seed in any planting endeavor is imperative for its success.
- The quality of the seed can only be maintained through appropriate seed technologies.

SCOPE

- Seed technology encompasses all activities carried out to enhance storability, germinability, vigor and health of the seed.
- Activities include harvesting, transporting, handling, storage, testing, grading, documentation, processing of seeds and germination of seeds (Note: These activities will be described in the proceeding pages.

IMPORTANCE AND SCOPE OF NURSERY MANAGEMENT

Armando M. Palijon

DEFINITION

- Agroforestry nursery management is a system which includes three distinct but interrelated subsystems: establishment and development; planting stock production, and nursery administration.

IMPORTANCE

- Nursery plays an important role in any development endeavor like agroforestry, orchard, tree farming, reforestation or rehabilitation of degraded lands.

- These development activities would not only need species that are suitable to the existing conditions but more importantly high quality planting stocks that are made available at sufficient quantity at the right time.

- High quality planting stocks are well-conditioned or hardened, healthy and vigorous, and have balanced root and shoot which enable them to have higher chances of survival and successful growth and development when outplanted in the field.

- Such quality and quantity of planting stocks can be produced from a well-managed nursery -- a place where the desired tender care/cultural management practices required by the young plants are provided.

SCOPE

- Nursery establishment and development subsystem primarily includes preparatory activities such as selection of the site for the nursery, survey, mapping, designing, layouting, construction and development.

- Planting stock production subsystem can be divided into four phases similar to the production lines in a factory to produce a product in this case planting stocks or materials. These phases include pre-sowing, propagation, tending (i.e. care and maintenance) and dispatch.

- Nursery administration subsystem makes the system operate. It includes planning, organizing, staffing, motivating, budgeting, controlling and/or monitoring and evaluation and other management functions.

- Figure 1 presents the schematic diagram of the nursery management system.

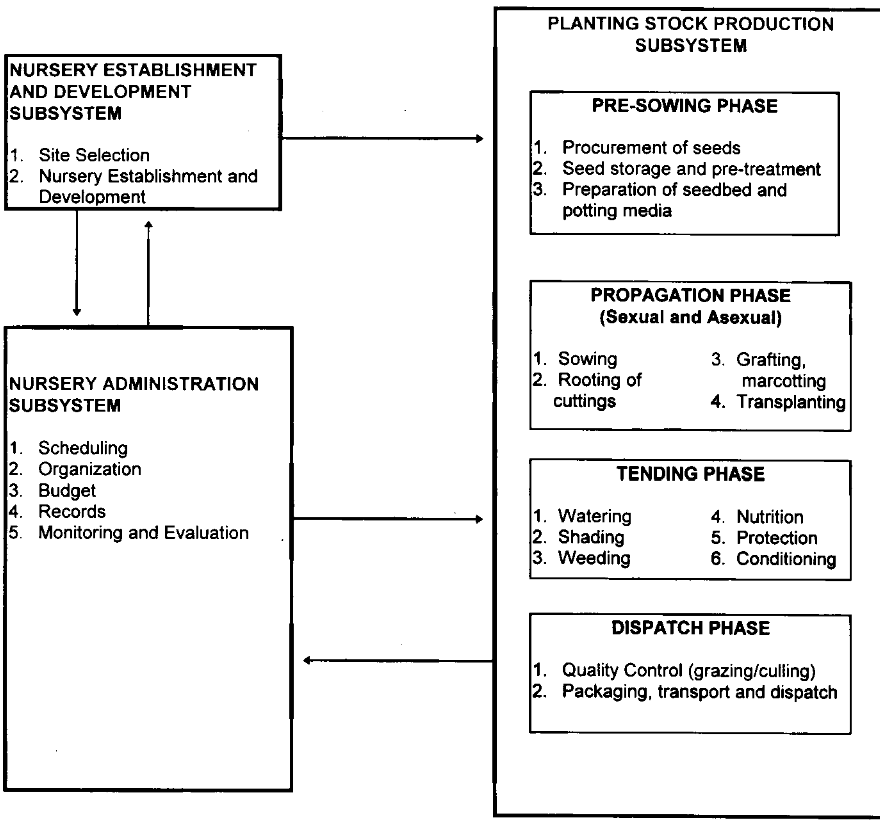

Figure 1. Forest Nursery Management System.

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GENERAL PRINCIPLES OF SEED TECHNOLOGY AND NURSERY MANAGEMENT

SEED COLLECTION

Portia G. Lapitan

CONSIDERATIONS IN SEED COLLECTION

- Collection of tree seeds may be carried out for a number of purposes -- for large scale regeneration of forest, species introduction and provenance research or conservation of gene resource.

- Collection trip should be well planned to maximize collection of quality seeds in the shortest time possible. This way the time and effort utilized for the purpose are minimized.

- Trees from where to collect the seeds should be marked and should be considered based on genetic superiority of certain desirable traits.

- The proper timing of collection is also a critical factor to consider as it affects the quality of the seeds.

- Collection of seeds should be done at a time when most of the seeds from the trees are mature enough to harvest.

- Collection should be confined to dominant larger trees which have been proven to bear seeds with greater viability and vigor.

- Collection is usually done at a time when more than 50% of the seeds are mature enough to be naturally dispersed.

- For some species, the best indicator is the color of the fruit. Fruits of *G. arborea* may be collected as soon as their color changes to yellow orange or golden.

- Other possible indicators of seed maturity are the moisture content of the seed, specific gravity which have been proven reliable for conifers, embryo and endosperm development, constancy of the dry weight, and the chemical content of the seed.

METHODS OF SEED COLLECTION

- The usual method employed is collection from the ground. Seeds collected from the ground are more inferior than those collected from the trees. However, it has been found that *G. arborea* seeds collected from the ground perform better than those collected from the trees. This should be accepted with caution, nevertheless, as the seeds that may have been collected from the trees may still be immature. The portion of the tree where seeds are collected from the standing trees may also affect the quality of the seeds.

- Seeds can be collected from natural seed fall or from standing trees. Rarely are seeds collected from felled trees.

- It is recommended to collect seeds from the outer portion of the crown than from within to avoid inbreeding.

- On the other hand, in trees located at the periphery of the seed stand, it is advisable to collect from within the crown to avoid possible outcrossing with inferior trees outside of the stand.

COLLECTION PRACTICES IN THE PHILIPPINES

- The bulk of seeds collected in the country is for large-scale regeneration or reforestation.

- The usual way seeds are collected considers only the ease with which largest collection can be attained.

- It would appear from the seed lot made available to reforestation projects in the Philippines that seed collectors do not pay much attention to the proper time of collecting seeds.

- Collection is not confined to dominant larger trees which has been proven to bear seeds with greater viability and vigor because it is more difficult to collect from these trees.

- Although the superiority of collecting seeds from plus trees is now recognized, the dearth in good seed sources has driven seed collectors to harvest seeds from low-quality mother trees.

SEED PROCESSING AND HANDLING

Portia G. Lapitan

PRINCIPLES OF SEED PROCESSING

- Seed processing involves the removal from a seed lot of:
  - ⇒ debris
  - ⇒ chaff
  - ⇒ contaminating seeds of other crops
  - ⇒ poor quality seed

- The objective of processing is to upgrade the quality of the seed and to obtain maximum percentage of pure crop seed with maximum germination potential.

- This process is particularly important for small-seeded species such as the following where the minuteness of the seed makes estimation of the seed number very difficult to do:
  - ⇒ *Eucalyptus camaldulensis*
  - ⇒ *Anthocephalus chinensis*
  - ⇒ *Casuarina equisetifolia*

- The number of seeds that will produce seedlings can be estimated based on the pure live seed percentage.

Pure live seed percentage = pure seed content x % germination x 100

↳ If pure seed content is 95% and percent germination is 93% then the pure live seed percentage is 88.35%.
↳ This means that from a gram of *Eucalyptus camaldulensis* seeds, for example, 88.35% of it will give rise to seedlings.

- A number of methods are employed in the processing of seeds. Whatever method may be employed, it should be one that would cause the least damage to the seeds if the quality of the seeds is to be maintained.

ACTIVITIES IN SEED PROCESSING

- Activities performed during seed processing which affect the quality of seeds:

1. Extracting the seeds from the fruit.

a) *Pinus kesiya, Casuarina equisetifolia* and *Alnus maritima* are usually manually extracted from their cones here in the Philippines.

The cones are first sundried to hasten its opening.

The seeds are then extracted by shaking the cones in a thresher or a sieve to facilitate the release of the seeds from cones.

b) A similar technology is adopted for species with seeds in pods like *Leucaena leucocephala*, *Parasenanthes falcataria*, *Acacia auriculiformis* and others.

The pods which are collected intact are first induced to dehisce by sundrying before the seeds are removed by shaking or by hand.

c) *Gmelina arborea* and other fleshy fruits like *Vitex parviflora*, are processed differently.

The method is more a cleaning activity rather than extraction.

The fleshy pericarp (fruit wall or flesh) is removed by soaking the seeds in tap water until the pericarp softens and loosens from the part of the fruit containing the seed.

Prolonged immersion in water might lead to fermentation (anaerobic respiration) which is harmful to the seed.

It is reported that the problem of fermentation can be solved by exposing the seeds to running water.

d) The seeds of *A. chinensis* and *Ficus spp.* are extracted differently

The fruits are macerated manually, usually by passing the fruit through a number of sieves until the seeds are separated from the other parts of the fruit.

e) Winged fruit of the species of *Dipterocarpaceae* are "minimally processed" by simple dewinging.

2. Seed Drying

- The next activity undertaken particularly for seeds extracted from fleshy fruit is drying. Proper drying protects the seed from deteriorating.

- The usual way of drying seeds performed in the Philippines is either by sundrying or air-drying whichever is most convenient to do.

- The seeds are scattered in a mat or on a cemented area directly exposed to sunlight in the sundrying method.

- The air-drying method involves spreading the seeds on a mat or an elevated sieve made of wire mess and exposing to windy condition.

- The length of time the seeds are dried varies from species to species.

- Seeds should not be overdried or else they will become brittle and will be prone to damage.

- Use of desiccants to dry the seeds has also been tried and studied.

- It was observed that air-drying appears to be a better method than sun-drying.

3. Seed Cleaning/Upgrading

- After the seeds are dried, the seed lot should be cleaned, the impurities separated from the seed. For large seeds, this task is easy to do but for minute seeds this is specially tedious and time-consuming.

- For *A. chinensis* and *Lagerstroemia speciosa* purity analysis revealed 34.1% and 79.9% purity, respectively, even after the usual cleaning procedure.

- A common method of cleaning the seeds employed in most areas of the Philippines is winnowing, a method which takes advantage of the velocity of the wind in separating the light materials from the seeds (e.g. wings).

4. Seed Sorting

- Seeds should be sorted either by size or weight. Sorting of seeds allows for segregating seeds by class.

SEED TESTING AND CERTIFICATION

Portia G. Lapitan

SEED TESTING

- Seed testing provides information on the planting value of a particular seed lot.

- Seed testing is normally performed with the primary objective of obtaining accurate and reproducible results regarding the percentage of seeds which can be expected to produce normal plants under favorable conditions; purity composition; vigor and seed health status of a seed lot (USDA, 1952).

- Seed testing normally entails conducting a series of separate standard individual tests which include the viability test, purity test, seed health test and MC test.

- Results of seed testing and field verification form the bases of seed certification.

VIABILITY TEST

- The seed test that determines the percentage of seeds that can be expected to produce normal plants under favorable conditions is called a viability test. This kind of seed test is probably the most often employed test.

- Sample seeds are randomly selected for this test. Information gathered from the test tells whether a given seed lot is worth sowing or not.

- Table 1 lists down a number of methods of viability testing used in the Philippines.

Table 1. Different Methods of Viability Test Used in the Philippines.

I. Direct Testing
- Actual Germination Test

II Indirect Testing

a. Physical test

1. cutting test
2. flotation
   a. air-flotation
   b. water-flotation
3. color and size test

b. Biocr.emical test using tetrazolium dye

c. X-ray test

DIRECT TEST = Actual Germination Test

- Bacdayan (1959) exhausted the literature on Philippine forest tree seeds till 1959 and his work revealed that viability tests using the actual germination test have been conducted on a number of species by a few individuals.

- Percent viability of readily germinable seed species can be easily assessed by this method but for dormant seeds or difficult-to-germinate seeds, various pre-treatments have to be performed first to hasten germination and to approximate the true percent viability of a given seedlot.

- Table 2 lists the germination tests of pre-treated seeds of a number of forest species performed as early as 1935.

for viability tests of tree species, however, has yet to be outlined.

Table 2. Early germination studies of Philippine forest tree seeds and corresponding pretreatment used to hasten germination.

SPECIES	PRE-TREATMENT USED TO HASTEN GERMINATION
Canarium ovatum (Pili)	• Soaking seeds in tap water for 10 days (Miras, 1935)
Callophylum inophylum	• Complete shelling of seeds (Paras, 1935, 1939)
Albizia acle (Akle)	• Soaking of seeds for one hour in 36 NH_2SO_4 (Delizo, 1937). • Exposing the cotyledons by making holes or by reducing thickness of the tests (Cruz and Chinte, 1940) • Soaking in hot water with an initial temperature of 80° for 15-30 hrs. (Jacalne, 1958)
Tectona grandis (Teak)	• Storing seeds in an open shaded pit for 60 days (Denoga, 1939) • Stratifying in pit with sawdust for 45-49 days (Fabia, 1946) • Stratification for 21 days (Rosario, 1959)
Bauhinia purpurea (Fringon morado)	• Soaking tap water for 15 hrs. (Azurin, 1947)
Albizia lebbeck (langil)	• Soaking in tap water for 15 hrs. (Baysa, 1947)
Intsia bijuga (Ipil)	• Soaking in tap water for 15 hrs. (Azurin, 1947) • Mixing with wet wood ash and cogon mulching (Chinte, 1951)

INDIRECT TEST

- Viability of seeds may also be determined indirectly by studying the physical and biochemical properties of the seed.

- This kind of viability testing has already been employed and found useful for some tree species in the Philippines

Physical and Cutting Tests

- The cutting test involves examining the embryo exposed by cutting the seed.

- Although the test can be performed in a much shorter period of time than the germination test, skill and familiarity with the seed is essential for an accurate assessment of percent viability of the seed.

- The cutting test performed on *Leucaena leucocephala*, *Intsia bijuga* and *Lagerstroemia speciosa* gave a fairly accurate and reliable viability assessment of these seeds as the germination test (Viado, 1938).

Flotation Test

- Another indirect method of determining seed viability popular before and still in use now is the flotation test either by air or in water.

- The seed lot is subjected to a determined wind velocity or submerged in water respectively.

- Seeds carried by air or floating in water are considered non-germinable or not viable.

- The weight of the seed is used to determine viability as the weight has been found to correlate with the amount of reserve food within the seed which is utilized to drive reactions of germination (Lopez & Grave, 1973).

- Examples of tree seeds which can be efficiently assessed by the flotation test are *Swietenia macrophylla* and *Pinus kesiya* (Veracion, 1966) among others.

- In other countries, specific gravity is used instead of the plain weight of the seed. This test was proven reliable in determining viability of conifers.

Color and Size Test

- The color and size of the seeds have also been used to gauge the germinability or viability of seeds.

- The color indicates maturity of the seed and since good germination would only occur when seeds are mature (Roberts, 1973a), color may be used to determine seed viability.

- The test however is not a very accurate way of viability testing as color and size of the seed may be affected by so many factors aside from maturity of seed.

- Examples of the species where maturity of seeds is gauged by color are Anabiong, Benguet Pine and some species of Dipterocarps.

- Effects of seed size on germination of *Shorea contorta* (White Lauan) have been studied and results showed that total germination of big seeds is significantly higher than medium and small-sized seeds.

- Heavier *Benguet pine* seeds obtained a higher percent germination, produced larger and have more vigorous seedlings and lower % mortality than smaller seeds.

Biochemical Test

- Viability of seeds can also be determined by using chemical dyes that would test the metabolism of seeds.

- One of these dyes is the tetrazolium dye that reacts with dehydrogenase enzyme of the seed.

- Presence of the dehydrogenase implies that the seed is metabolically active and hence capable of germinating.

- Reactions of the tetrazolium dye and the enzyme of the seed produce a deep carmine red coloration in the embryo.

- Viability of the seed is indicated by this color formation.

- The test can be performed in 1 to 2 days time.

- In the Seed Biology Laboratory of CFNR, the development of rating standard for each tree species using the tetrazolium test is under way.

- Specific procedure found effective for seeds of *Leucaena leucocephala, Albizia saman, Swietenia macrophylla* and *Albizia procera* using the tetrazolium dye as viability indicator has been outlined.

Seed Health Test

- The main principle and purpose of this test is to detect and to identify the seed-borne organisms in order to quantify the extent in which a seed lot has been contaminated by them (ISTA, 1986).

- So far in the Philippines seed health test of forest species in its true context is not being practiced.

- Although physical examination of the seed for presence of contamination, particularly insects, is sometimes conducted, the extent to which the seed lot is contaminated is not assessed.

- Such practice has been occasionally reported only by some researchers who need good quality seeds to ensure the conduct of a good research work. Never has it been reported as a routinary work in nurseries.

Moisture Content Determination

- Second to the viability test, we may say that moisture content determination is usually performed on seeds.

- This is performed however in areas where equipment for this purpose is available and not in forest nurseries of remote areas.

- The best method of moisture content (MC) determination involves oven-drying the seed in a temperature condition of 103 $\pm$ 2°C for 17 $\pm$ hours.

- Moisture content is computed using the formula:

$$MC = \frac{\text{Fresh weight - Ovendry weight}}{\text{Fresh weight}} \times 100$$

SEED STORAGE

Portia G. Lapitan

PRINCIPLES OF SEED STORAGE

- Seed storage is a technique where seeds are kept in an environmental condition such that they are maintained alive and yet prevented from germinating.

- Respiration has to be controlled in the level that would keep the seed alive but would not support germination.

- The usual purpose of this technique is to keep excess viable seeds for future use especially during seasons of the year when seeds are no longer available from the trees.

CONSIDERATIONS IN SEED STORAGE

- The two most important factors to affect seed metabolism while in storage are temperature and seed moisture content.

- For most seeds, control of these two factors has successfully maintained seed viability for a long period of time.

- Decreasing temperature and seed moisture content to a certain level depending on the species, has effectively decreased the metabolism in seeds such that germination of living seeds has been prevented.

- A study conducted by the CFNR showed the pre-storage drying of *Anisoptera thurifera* seeds resulted in a viability/period of only two to three weeks. On the other hand, those kept undried in an air-conditioned room retained the viability till the seventh week after harvest.

- For storage temperature, it would be safer to try temperature treatments above 15°C first for species classified as recalcitrants to avoid chilling injury to the seeds. Subsequent adjustment can be done based on the requirement of the species.

- Seeds in storage should also be protected from attacks of insects and pathogenic microorganisms.

GENERAL TYPES OF SEED BASED ON STORAGE PHYSIOLOGY

- There are three general types of seed based on storage physiology -- orthodox, recalcitrant, and intermediate.

- Orthodox seeds can be stored successfully by drying the seeds and storing in sealed containers under very low temperature condition.

- Seeds classified as orthodox include the commonly used reforestation species like *P. falcataria, L. leucocephala, A. mangium* and other leguminous species.

- Dipterocarp seeds are found to die easily when dried a little below the fully hydrated condition. They lose viability in a relatively short period of time. Seeds like these are referred to as recalcitrant seeds (King and Roberts, 1980).

- Intermediate seeds are those with characteristics in between orthodox and recalcitrant. Seeds with characteristically high moisture content during harvest but can be dried like the orthodox belong to the intermediate type of seeds.

- Recalcitrant seeds cannot be stored in storage conditions commonly favorable for orthodox seeds. Recalcitrants are highly sensitive to desiccation/drying and are intolerable to low temperature.

- So far, storage studies on recalcitrant seeds particularly of dipterocarps have yielded information on desiccation rates of *Shorea contorta, Anisoptera thurifera, Hopea foxworthyi, Shorea polysperma* and *Parashorea malaanonan*. The critical moisture content below which the seeds will die has also been determined for *S. contorta* and *A. thurifera*.

SEED GERMINATION

Portia G. Lapitan

SEED DORMANCY IN REFORESTATION AND AGROFORESTRY SPECIES

1. Coat-imposed dormancy

- The most common type of seed dormancy manifested by a number of reforestation species is that caused by the seed coat -- the outermost covering of the seed

- Species found to possess this type of dormancy belong to the family *Papilionaceae* and *Mimosaceae* (Tran and Cavanagh, 1984) which include *Paraserianthes falcataria, Acacia mangium, A. auricoliformis, Sesbania species, Dalbergia, Calliandra*, and *Parkia.*

- The seed coat has been shown to inhibit germination through a number of mechanisms.

- In some species like lumbang (*Aleurites moluccana*), the coat, which is actually the endocarp, is too thick to allow for embryo expansion and germination.

- In others, the seed coat is covered by a cutin layer and/or suberin layer which prevent water from the external environment to penetrate the seed.

- The seed coat may also not allow germination to occur if it restricts oxygen to pass through which is exhibited by *Fraxinus excelsior.*

2. Dormancy due to the presence of germination inhibitors

- There are seeds that would not germinate because they contain germination inhibitors or they are enclosed by fruit tissues with germination inhibitor.

- Substances found to prevent the seeds from germinating include **coumarin** and **abscissic acid**.

- Others are inhibited from germinating in the presence of fruit juices because the fruit juice is too concentrated to allow for water to penetrate the seed (Salisbury and Ross, 1985).

- Examples of seeds found to be dormant because of germination inhibitors are tomato (*Lycopersicon esculentum*) and *Fraxinus excelsior*.

3. Dormancy due to immature embryo

- Some seeds are dispersed from the mother tree while their embryos are still morphologically immature.

- These seeds can only be made to germinate after they have gone through an after-ripening period -- the period during which the embryo continues to grow and develop to maturity after seed dispersal.

- Examples of tree species reported to require after-ripening period are Thailand acacia (*Cassia siamea*) (Komboo and Hellum, 1984), *F. excelsior* and some *Pinus* species (Copeland, 1976).

4. Dormancy due to specific requirement for light (Photodormancy)

- Some seeds do not germinate because their requirement for light has not been satisfied.
- Seeds requiring light for germination are called photodormant seeds.
- Some seeds usually germinate better when exposed to red light than the normal white light and are inhibited by blue or far-red light.
- Seeds covered with more maternal chlorophyll during ripening will require light to germinate while those without or with little will not (Salisbury and Ross, 1985).
- Kaatoan bangkal (*Anthocephalus chinensis*) (Gamboa, et al., 1976) and *Pinus sp.* (Sasaki), are examples of photodormant seeds.

5. Dormancy due to other fruit parts

- There are seeds which are prevented from germinating by their covering layers because these interfere with water imbibition of the seeds.
- Teak (*Tectona grandis*), Toog (*Combretodendron quadrialatum*) and yemane (*Gmelina arborea*) are good examples of this group of seeds.
- The velvety fruit wall of teak excludes water from its seed while the papery calyx wing of toog poses a barrier to the entry of water into its seed.

METHODS OF BREAKING SEED DORMANCY

- Several methods of breaking dormancy have already been developed through the years.

- The method appropriate to break one type of dormancy is less likely to break another type as these techniques were developed depending on the nature of seed dormancy.

1. Methods of breaking coat-imposed dormancy

- In the case of coat-imposed dormancy, the methods are applied to overcome the barrier imposed by the seed coat either to entry of water, of oxygen or to embryo expansion.

- The methods employ physical, mechanical or chemical means to weaken the seed coat.

- The specific methods used to break this kind of dormancy are scarification, nicking the seed coat, impacting or shaking the seeds, dry and wet heat treatment of the seed, boiling seed within a prescribed period, acid treatment and other chemical treatments.

- The effectiveness of any one of these methods varies from species to species. Table 1 lists down seed pretreatments found suitable for some species as early as 1935 (Bacdayan, 1959).

- The pretreatments to enhance germination of dormant seeds when performed without caution may cause excessive damage to the seed.

Table 1. Seed pretreatments found suitable for some species.

SPECIES	METHOD OF PRETREATING TO OVERCOME DORMANCY*
Akle (*Albizia acle*)	• Exposing the cotyledons by making holes or by reducing the thickness of the testa (Cruz & Chinte, 1940) • Soaking the seeds for one hour in a 36N sulfuric acid (Delizo, 1938) • Soaking in hot water with an initial temperature of 80°C for 15-30 hours (Jacalne, 1958)
Anabiong (*Trema orientales)*	• Heating the seeds in water at varying temperature ranging from 38°C to 58°C (Lopez, 1953)
Bitaog (*Callophyllum inophylum*)	• Complete shelling of the seeds (Parras, 1935; 1939)
Cutch tree (*Acacia catechu*)	• Soaking in tap water for 15 hours (Chinte, 1951)
Eucalyptus dives	• Water soaking for 48 hours (Boden, 1957)
E. panciflora	• Cold and moist treatment (Pyror, 1954) • Water soaking for 48 hours (Boden, 1957)
E. gigantea *E. niphophilla*	• Cold and moist treatment (Pyror, 1954)
Fringon (*Bauhinia monandra*)	• Soaking in tap water for 30 hours (Chinte, 1951)
F. morado (*B. purpurea*)	• Soaking tap water for 15 hours (Azurin, 1947
Ipil (*Intsia bijuga*)	• Mixing with wet wood ash and cogon mulching (Chinte, 1951) • Soaking in tap water for 15 hours (Azurin, 1947)
Kupang (*Parkia javanica*)	• Soaking in water with an initial temperature of 50°C for 15 hours (Clemente, 1948)

SPECIES	METHOD OF PRETREATING TO OVERCOME DORMANCY*
Langil (*Albizia lebbeck*)	• Soaking in tap water for 15 hours (Baysa, 1947)
Lumbang (*Aleurites moluccana*)	• Seeds are mixed with soil in an improvised container with perforations at the bottom, covered with burlap, watered and exposed to the sun for a week (Tamesis and Natonton, 1958)
Pili (*Canarium ovatum*)	• Soaking seeds in tap water for 10 days (Miras, 1935)
Siar (*Peltopermum inerme)*	• Soaking in hot water with an initial temperature of 80°C and allowing to cool for 15 hours (Chinte, 1951)
Supa (*Sindora supa*)	• Soaking in hot water with an initial temperature of 50°C for 15 hours (Salvador, 1951) • Mixing with wet wood ash for 15-30 hours (Chinte, 1951)
Teak (*Tectona grandis*)	• Storing the seeds in an open shaded pit for 60 days (Denoga, 1939)

- It was observed that the boiling technology appeared to be appropriate only for a few years after seed collection and can cause damage to the seed for seeds which have been kept longer in storage.

- *Paraserianthes falcataria* seeds kept for 3 years in storage and boiled for 1 minute before germinating gave significantly lower % germination than unboiled control seeds.

- Seeds from the same seed lot after 7 1/2 years in the refrigerator were also observed to germinate in a day without any pretreatment and reached 50% germination in 6 days. Those boiled did not germinate at all.

2. Methods of Breaking Dormancy due to Germination Inhibitor

- The germination of seeds with germination inhibitors can be enhanced by treatments that would allow for the removal of germination inhibitors.

- In tomato, where the inhibitor is reported to be in the mucilagenous coating of the seed, seeds would readily germinate after sundrying the seed or washing the seeds with diluted acid solution.

- These treatments were shown to destroy and remove the inhibitor from the seed, respectively.

- In other seeds, washing the seeds in running water may do the job. This is particularly applicable for water-soluble germination inhibitors.

3. Methods of Breaking Dormancy due to Immature Embryo

- For seeds that would require after-ripening, it is recommended that they be exposed to conditions that would hasten the maturation of the embryo.
- For some *Pinus* species, cold stratification before germination has been found effective.

- Cold stratification was observed to cause the embryo to grow extensively due to enhanced transfer of food reserve from the storage depot of the seed.

- For *Cassia siamea*, allowing the seeds to remain in the fruit for quite some time after the fruit has been shed from the mother tree improves the germination of these seeds.

4. Methods of Breaking Dormancy
due to Specific Requirement for Light (Photodormancy)

- The exposure of Kaatoan bangkal (*A. chinensis*) seeds to red light has been shown by the author to significantly facilitate and improve its germination.

- In contrast to K. bangkal, seeds of akleng parang (*Albizia procera*) and unik (*A. chinensis*) germinated better in dark condition than under light condition (Shulan, 1986).

- The germination rate of yemane (*Gmelina arborea*) was also found to be increased by direct exposure to high light intensity.

5. Methods of Breaking Dormancy due to other Fruit Parts

- In species cited previously to possess fruit parts which interfere with water imbibition of the seed, removal of these fruit parts has positively enhanced seed germination.

- For teak, removal of the velvety pericarp hastened germination by 21 days. Seeds without the pericarp germinated 7 days after sowing while those within the pericarp started germinating only after 28 days from sowing.

- In Thailand, for uniform germination, teak seeds in seed bed are covered with sawdust and lignite powder and the seeds are pretreated by alternate soaking and drying for 3 days prior to sowing.
- The removal of the papery wings of Toog has also induced germination of its seeds. Seeds sown with the wings intact did not germinate while those without wings gave 60.8% germination.

METHODS OF ENHANCING GERMINATION OF NON-DORMANT SEEDS

- Readily germinable seeds may exhibit uneven pattern of germination which prolongs the germination period because the extent of embryo development may vary from seed to seed.
- To shorten the germination period and at the same time make germination uniform, seeds may be given pre-sowing treatments.
- This involves a repeated cycle of controlled imbibition followed by drying back of the seeds prior to radicle emergence.
- This treatment prepares the seed for germination such that when they are actually sown all the seeds will germinate at the same time.
- The critical factor here is the level of water given during the pretreatment.
- Simple moistening of the seed will be enough. It should be minimal not to allow the seed to germinate.
- The use of salt solution during imbibition can also be resorted to. The most recent technology developed is the use of high molecular weight osmoticum such as polyethylene glycol or carbonaxes to regulate entry of water into the seed.

SUMMARY AND CONCLUSIONS

- A number of seed treatments have been developed to enhance germination of seeds which would not readily germinate.

- The effectiveness of any one of these treatments however depends greatly upon the nature of dormancy exhibited by the seed.

- The methods/treatments so far developed are for those seeds which have been established to possess specific seed dormancy.

- In these seeds, the problem of slow or non-germination has already been solved.

- With other seeds where the nature of seed dormancy is still less understood, the pretreatments are used on a hit and miss basis.

- This practice is dangerous as the treatments used may have an effect on the quality of the seedling that will be produced later.
- It is important that the nature of the block preventing germination to occur be clearly understood before appropriate technology is developed.

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ASEXUAL PROPAGATION TECHNIQUES

Flordeliza B. Javier

- Asexual propagation uses vegetative organs of plants in producing true-to-type plants.

- This method is adopted for perennial crops in general and specifically for fruit crop species from known outstanding/recommended varieties/cultivars.

- Crop production in fruit crop species in particular requires economic part, that is, the fruit to conform with the fruit quality standards.

- Quality planting materials therefore should be those seedlings that will produce and copy quality characteristics of outstanding/recommended mother plant species/varieties/cultivars.

- Perennial crops are known to be characterized by long growing period, that is, vegetative phase of growth ranging from 5-7 years or more before fruiting.

- It is vital, therefore, to ensure that planting materials are quality seedlings true-to-type or exact copy of the parent mother plant.

METHODS OF PROPAGATION

- There are several methods known for asexual propagation/vegetative propagation. One particular method, grafting, is being adopted for perennial plants specifically fruit crops. Grafting of fruit crop species is now a common and known commercial method for true-to-type propagation.

- There are several methods/procedures/techniques of grafting. Researchers and action research as well showed that cleft grafting and modified shield budding and patch budding are the leading techniques. The techniques of shield budding for citrus; patch budding for santol; cleft grafting for many are practiced. Cleft grafting has been considered recently as the standard procedure for commercial mass/volume true-to-type propagation.

- Cleft grafting is a relatively simple technique, the skill easily mastered and practical.

MOTHER/PARENT PLANTS

- In the absence of scions from the mother plants available (for sale) from government institutions and line agencies, growers may grow their mother plants for future orchard establishment.

- Recommended quality planting materials of various fruit crop species may be procured from accredited commercial nurseries, regional DA stations, agricultural state colleges and universities.

PROCUREMENT AND PREPARATION OF SCIONS

- Bearing mother/parent plant is the source of scions.
- Scions are collected prior to grafting operation.
- Scions are cut from terminal branches of previous season's growth.
- The size (diameter) of scions approximate the size of the rootstock seedlings at 30-42 cm stem diameter from soil.
- The length is 3-5 cm longer that the actual graft to give allowance for the operation techniques.

MATERIALS AND TOOLS

- Plastic (transparent) strips about 1 cm to 1 inch diameter cut from plastic bags, 4 x 11 cm, .000006 mil. These strips are used for tying grafts and scion cover.
- Plastic (transparent) cover for the scion protection is also used. The plastic cover is the common ice candy bag.

CLEFT GRAFTING OPERATION

1. Materials and tools needed

- Sharp grafting knife (always clean before and after use)
- Plastic strips (1 cm wide cut from ice candy bags or refrigerator ice bags, 4 x 10 cm).

2. Procedure

- Detop seedling rootstock (at stem portion with 1 or 2 pairs of leaves left below cut) and make incisions on middle portion.
- Shape scion base into wedge (no curvature).
- Smoothen edge (base) with one cut.
- Insert scion onto the rootstock. Make sure one side of the cambium layer of the scion is in contact with that of the rootstock in case the scion or rootstock is slightly bigger in diameter.
- Tie with plastic strip to secure parts in place. Tying should extend towards the tip of the scion (apical bud).
- Cover scion with ice candy bag.
- Remove cover after flushing and before crowding of leaves inside.

CARE OF GRAFTED PLANTS

- Regular watering is done on individual plants.
- Further growth is needed before field planting.

FIELD PLANTING

- Grafted plants/seedlings are ready for field planting as soon as the first flush becomes mature. This will take about 3 to 6 months after grafting operation.
- Proper care of the seedlings planted in the field is needed.

NURSERY SITE SELECTION, DESIGN AND LAY-OUT

Armando M. Palijon

CRITERIA FOR THE SELECTION OF AGROFORESTRY NURSERY SITE

- Suitability of a site for a nursery can be determined by the following:

Location and Accessibility

- Must be centrally located so that the planting stocks need not be transported over long distances
- Handling and transport is less costly and the hazards or risks of damage to stocks during transport are likewise reduced
- Good access to and within the nursery makes the movement of resources efficient

Size and Ownership of the Area

- Must be wide enough to accommodate the nursery buildings, infrastructure and other facilities normally seen in a nursery
- Must have sufficient area for nursery beds which are necessary to produce the required number of planting stocks

- Generally, about 60% of the nursery area may be devoted to nursery beds and 40% for paths and other nursery facilities

Size of the nursery is determined based on:

a) Level of annual production -- bigger area is needed for large number of stocks to be produced every year

b) Method of raising seedlings -- potted seedlings occupy more space than bareroot seedlings.

c) Area needed for buildings, paths, roads, irrigation canals and others plus some allowance for future expansion

d) Nursery life of plants or lengths of time the planting stocks have to remain in the nursery

Water Supply

- Sufficiently available water throughout the year is of utmost importance not only in selecting but also in determining the size of the nursery.

- High quality stocks can be produced with proper and uniform watering all throughout the year.

- Adequacy of water supply is best determined during the dry season since it is in this season that the water supply is slow and the nursery consumes the greatest amount of water.

- The amount of water required in the nursery will depend on:

a) Size of the nursery – a bigger nursery needs more water

b) Type of soil -- sandy soils need more water due to their low water-holding capacity

c) Method of irrigation -- flooding and furrow irrigation need ample water supply than overhead irrigation

d) Species - Narra, Teak, Eucalyptus and Agoho reportedly consume less water than other species like Kaatoan Bangkal, Mollucan Sau, Mahogany and dipterocarps

- Water quality is as important as quantity in successful nursery operations.

- Water containing some concentration of chemicals may be detrimental to plants. Examples are:

a) Water with more than 500 ppm of dissolved solids raises pH of the soil. This, in turn, favors incidence of damping-off and root rot, inhibits iron metabolism which causes chlorosis.

b) Water with at least 100 ppm calcium or 125 ppm bicarbonate. This, if used, will produce appreciable harmful effects to plants.

Soil and Vegetation Cover

- Ideally, the soil available in the nursery for planting stock production should not be greatly different from the soil in the planting site.

- If containerized or potted stocks are to be raised, soil in the nursery beds may not necessarily be of high quality. However, there must be a place nearby where good potting soil can be collected.

- Bareroot, naked-root or open-root stock production requires good quality nursery soil with favorable depth, structure and texture, free draining and porous and contains high proportion of organic matter.

- Physical properties like texture and depth are more important in selecting a site than soil fertility. The latter can easily be corrected and maintained through the use of organic and inorganic fertilizers

- Most desirable nursery soils are sandy loam and/or loamy soils preferably with high humus content and pH between 5.5 and 6.5.

- Soils with a pH of 7.5 or higher should be avoided as nursery site. At this pH, excess carbonates and alkalies in the soil create much difficulties for raising seedlings.

- A concentration of more than 500 ppm of soluble salts in the soil solution produces unhealthy, poor planting stock. This is due to chlorosis, damping off, phosphate and other nutritional imbalances and crusting due to deposition of salts brought to the surface by evaporation.

- Vegetation cover is a good indicator of the fertility and average moisture conditions of the site

- Available areas for nursery development in the upland are often cogonal hence characteristically low in fertility, acidic and low in moisture content.

Topography

- Nursery site should be nearly level. It is easier to carry out nursery operations in this kind of landform. Likewise, machineries like tractor and plow can be easily employed in site development.

- A gentle slope of 1 to 2 percent is allowed for average soil conditions like sandy loam or loam since it permits sufficient drainage.

- For light sandy soil, the surface must be completely level because surplus water will drain quickly into the soil.

- Sites available for agroforestry development are located in the uplands where the terrain is sloping. In such case, terracing is done which makes construction of nursery expensive and moving of materials and plants within the nursery laborious.

Labor

- A nursery should be nearer to the source of labor needed particularly during peak nursery operations.

- Women are especially effective in nursery work that does not require physical strength.

- More often, women constitute more than 50% of the total labor force in the nursery. They are more efficient and apparently are better adapted to some nursery works like weeding that need patience.

DEVELOPMENT OF THE NURSERY AREA

Design and Layout of the Nursery

- Nursery must be carefully planned to ensure efficient production of seedlings. Thus, it must be designed in such a way that it will allow smooth and systematic movement of people, machines and materials. This will save a lot of effort, time and resources.

- Important considerations in the design and layout of the nursery are:

a) Area must be compact, regular in shape, nearly square if possible. This reduces the length of the boundary fence and minimizes time of travel of workers from one part of the nursery to the other.

b) General lay-out should conform with the topography or landforms, needed access, irrigation and drainage.

c) Design should bear detailed sketch of all the compartments including:

- ♦ Location of buildings and other facilities
- ♦ Water distribution and storage facilities, irrigation and drainage system
- ♦ Size and location of the beds (seed and potbeds)
- ♦ Size and location of roads, driveways, walkways, turnarounds
- ♦ Windbreaks, fences and other essential facilities
- ♦ Site must be carefully staked out on the ground based on the development plan before actual clearing and leveling operations are started.

Clearing the Vegetation, Grading and Levelling

a. Remove vegetation particularly shrubs and grasses. If there are existing trees, retain those that are not within the compartment for nursery beds.

b. Stumps, roots, stones and unwanted materials must be removed from the site and utilized for compost making.

c. The area must be graded and leveled according to the requirements. If the area is sloping, bench terracing should be done.

Construction of Nursery Infrastructures

- Infrastructure facilities in the nursery and their specifications are:

a. Road and pathway system

1. Interior road must be wide and adequate to provide turning space for machines. A 6-meter or 20 feet wide road is recommended for operating and turning motorized equipment as well as allowing for access to various parts of the nursery.
2. A 3- to 4-meter strip down the center of the 6-meter road must be surfaced with fine rock or crushed gravel to make it serviceable throughout the year.
3. Surfacing material should not spread to the stock production areas and mix with nursery soil. This is important particularly if the surfacing material contains calcareous soils and other materials that would affect acidity.
4. Pathways of 1/2 to 1 meter are necessary.

b. Fences and hedges

1. Permanent fences are necessary for protection from grazing and other large animals.

2. Galvanized wire netting is well suited for permanent nurseries.

3. Thick hedges can be used as live fence. One or two rows of shrubs completely around the nursery and within the nursery around each compartment may be established to protect the seedlings from strong wind.

c. Water supply/irrigation system

1. Essentially the most critical facility in an agroforestry nursery is water supply/system.

2. Sources of water can be from outside (creeks, springs and river systems) or inside (underground source) the nursery.

3. Water from outside sources can be brought to the nursery either through gravity or power-generated pump.

4. Gravity is used when the source of water is located upslopes from the nursery. It is more economical hence is more preferred.

5. Power-generated pump is used when water source is downslope relative to the nursery. It is more expensive and not very reliable.

6. Within the nursery, water can be distributed in three ways: open ditches, surface pipes, and underground pipes.

7. Open ditches are relatively inexpensive but require regular maintenance, more area and, if not regularly maintained, water may be lost due to seepage. Ditches also impede travel and movement of machines.

8. Surface pipes can be easily moved from one part of the nursery to another. They can be reduced and adjusted if needed. However, water in exposed pipes are usually heated which when used may cause damage to the seedlings.

9. Underground pipes eliminate the shortcomings of the previous types. However, these would require high initial investment, and are more applicable to permanent nurseries.

Construction of Nursery Buildings and Facilities

- Necessary buildings and facilities in the operation of the nursery include:

1. Office building
2. Laborers/Personnel quarters
3. Tool room
4. Seed storage room/Seed house
5. Green house/propagation shed
6. Garage and workshop
7. Soil shed
8. Potting shed
9. Composting shed

Basic Nursery Equipment/Tools

1. Soil shredder
2. Soil mixer
3. Wheel barrows
4. Trowels
5. Brush cutter
6. Pruning saws
7. Planting hoes
8. Pressure hand sprayers
9. Spades

10. Shovels
11. Pruning shears
12. Lopping shears
13. Budding and grafting knives
14. Flat bars
15. Hauling and service vehicle
16. Farm tractor
17. Pick mattocks

Construction of Nursery Beds

- Nursery beds can be pot beds, seed beds and transplant beds.

- Large proportion of planting stocks in nurseries are raised in containers/pots. Some important species, however, are still raised in beds before transplanting to containers or to the field.

- Seeds, if not directly sown in pots, are either germinated in seed boxes or in seed beds.

- Fine or small and delicate seeds are normally germinated in seedboxes. Medium to large seeds are germinated in seed beds particularly if the soil is highly favorable.

- Once the seedlings in the beds have reached the desired sizes they are either transferred to containers/pots or transplant beds to produce potted and bareroot stocks, respectively.

- Use of nursery beds:

a) Pot beds are used for the recovery and hardening of the containerized stocks.

b) Seed beds are intended specifically for germination and early growth stages of the seedlings.

c) Transplant beds are designed to improve the quality of the seedlings. Transplanting retards growth of tops and stimulate the development of more fibrous lateral root system having more lateral feeding rootlets.

- Seedbeds may range from 1/12th to 1/16th of the total area of the transplant beds, depending on the length of time of growing in each type of beds.

- Procedure in nursery seedbed construction is as follows:

a) Soilworking -- Seedbed is prepared manually by digging with spades, digging forks or any suitable tools. If the area is large, the land can be worked using carabao- drawn plow or small tractor with soil working attachments.

♦ Soil is thoroughly prepared by turning the soil several times, breaking the soil lumps and removing the rhizomes, roots, stones and other undesirable materials.
♦ Soil in the seedbed can be improved by screening and adding sand and humus.

b) Lining out -- Preparatory to forming the beds, a measuring line is stretched along the two sides of the compartment on which the ends of the beds abut.

- Plastic strings fastened to wooden stakes would make good planting lines. Stakes are driven to mark the sides of the beds and the foot paths.

- Lines are stretched across the compartment and fastened to the stakes thus marking off the beds and the paths.

c) Elevating the beds -- Soil from the paths can be added to the beds to make them elevated. The surface of the bed is shaped with an ordinary garden rake and is brought to a uniform contour.

d) Elevation of the beds above the paths depends upon their width, character of soil and method of irrigation.

- Seedbeds more than 4 ft are seldom raised. The surface however should be somewhat rounded to bring the middle portion higher than the margin.

- Better drainage on soils requiring such can be obtained by raising the center 1/2 to 3 inches above the sides.

- On porous soils where water does not stand even after prolonged rain, the beds need not be raised appreciably above the paths or made higher in the middle.

e) Rolling the bed -- After the beds have been prepared to the desired shape and contour, roll them to make the surface soil firm, more retentive of moisture particularly if the soil is light and sandy. Rolling is oftentimes done after sowing. This presses the seeds into the soil thus permitting more uniform covering.

f) Size and layout of the seedbeds depend on the cultural management activities to be employed, like shading, watering and soil working.

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SOIL/MEDIA PREPARATION: MIXING AND STERILIZATION

Armando M. Palijon

SELECTION OF MEDIA

- Production of high quality planting stocks (seedlings or vegetatively propagated stocks) requires that media should have the following properties:

  a. Porous
  b. Good water holding capacity
  c. Non-toxic
  d. Locally available
  e. Low-cost/easily affordable
  f. Free from weeds and destructive microorganisms
  g. Favorable (medium) pH
  h. Light weight
  i. Unique

- Considering all these properties, it seems that selecting the media would be hard due to limiting properties each medium may posses.

- The supply of quality media in adequate quantity is one of the main problems in raising potted plants considering that for the production of one million seedlings, about 500 cubic meters of potting media are required.

TYPES OF MEDIA

- Conventional and most popular media used for planting stock production are top soil and sand.

- Other media being used include sawdust, peat and sphagnum moss, humus and compost, coconut husk/coir plus decomposed manure (poultry and animal) and/or fertilizers.

PREPARATIONS AND APPROPRIATE MIXTURES

1. Collection

- Good topsoil can be collected under forest where it is taken from 15-30 cm.

- Top soil with the characteristics of loam or sandy loam and with pH ranging between 5.5 and 6.5 is preferred.

- Soil with pH value of over 7 is discarded as media due to cost of acidifying or lowering pH.

- Soil with low pH, can be easily corrected through liming

- Soil can be collected from nearby sources or obtained from distant places when transportation is available.

- Sand can be obtained from the nearest river or can be purchased.

- Compost can be prepared in the nursery.

- Other organic materials like sawdust, coconut husk/coir, sphagnum moss, or manure can be collected or purchased.

2. <u>Screening/Sieving</u>

- Soil and sand must be sieved preferably at its source.

- Coarse sieve with a ½-inch mesh fitted to wooden frame of approximately 1 to 1.5 m in size is used to exclude roots and stones.

3. <u>Storage in Soil Shed</u>

- After screening, the sieved soil and sand are brought to the soil shed where they are stored until they are needed.

- At the beginning of the rainy season there should always be a sufficient amount of topsoil stored in the shed to last for the time when it is too wet to collect soil in the open.

- In addition, there should be at all times an adequate supply of sand, compost and other organic materials that are locally available so that poor topsoil can be improved.

- A soil shed (potting shed) is a very important installation and is very necessary in almost all nurseries where containerized plants are grown.

- A soil shed is a simple shelter made of bamboo poles and thatched with cogon or palm leaves. For a more durable structure, one can use 2" by 2" timber and corrugated iron sheet.

- Ideally, there should be 5 or more spacious compartments for topsoil, sand, compost or any other material, ready mixed potting soil and empty containers.

- Under the same shed, there must be space for soil mixing, screening, potting, etc. There should also be a water tap nearby. More importantly, the soil shed should be accessible to motor vehicles.

4. <u>Mixing</u>

- Each particular species of plants responds differently to various types of media.

- Use of pure soil for some species may be enough but others require other media or mixtures of various materials at varying proportions.

- Clayey top soil and sand are not exactly favorable as media when used solely.

- Clayey soil tends to become compact and then absorb water slowly. When pots are watered from the above by sprinkling, the water often hardly moisten the upper 5 cm while the lower portions in the container remain dry.

- Sand, on the other hand, has low water-holding capacity and easily dries out. It can heat up quickly under the sun. This causes scorching of the stem tissues of the seedlings. Evaporation of water is also high, thus watering is required more frequently. Furthermore, the earthball quickly crumbles and falls apart when the container is opened during field planting.

- Appropriate media can however be prepared by mixing these clayey soil and sand with other materials like compost.

- There is no ready formula for mixing ideal media. This is because the quality of the topsoil may vary considerably from one source to another. Suitable mixing proportions have to be found by test and experience.

- For example, Jones (1984) tried to use mixture of sieved river sand, poultry manure and sawdust at 6:3:1, 6:3:2, 7:3:1 and 7:3:2 and found out 7:3:2: and 6:3:2 are ideal mixtures for *Acacia mangium* stock production.
- In Sarawak, Chai and Kendawang (1984) found topsoil, sand and peat moss at 5:3:1 a successful mixture for *A. mangium* seedling production.

- At the Asean New Zealand Afforestation Project (ANZAP) nursery in Tarlac, Philippines, the potting media being used are as follows: For *Pinus carribea var. hondurensis*, 50% river sand 50% clay soil by volume plus 3 kg NPK per cubic meter of potting.

The following are the potting media and type/size of containers found suited to various afforestation species in the Philippines:

Table 1. Potting media, type and size of containers found suitable for the different reforestation species in the Philippines

Species	**Potting Media**	**Type/Size of Container**	**Remarks/Source**
Benguet pine	Moss + Ordinary garden soil (OGS)	Polyethylene bags	Research Notes
Agoho	Sandy loam or OGS + humus (2:1)	Tin cans or bamboo tubes	Research Notes
Molave	Humus + sand (1:1) or OGS + humus (1:1)	Polyethylene bags	Lasmarias, et al.

Mahogany	Sandy loam Top soil/OGS + sand (3:1)	Tin cans/ Polyethylene bags	Kijkar, 1991
Kaatoan Bangkal	OGS + sand (1:1) or Humus + OGS (1:1) Humus + sand (1:1)	4"x6", 6"x9" plastic bags	Zabala and Sargento (1971); Domingo (1966)
Moluccan sau	Humus + sand (1:1)	plastic bags	
Giant Ipil-ipil	Top soil + sand (1:1) Top soil +humus (2:1) Moss + OGS (1:1) Moss + humus (2:1)	3"x5" plastic bags, bamboo tubes, veneer pots, etc.	Cadiz (19__) Malab (1980)
Yemane	Sandy loam + clay loam (1:1)	Polyethylene bags	PCARRD
Gubas	Sandy loam + clay loam (1:1)	Polyethylene bags	PCARRD
Bagras	sandy loam strained in 1/4 mesh wire	Polyethylene bags	PCARRD
Dipterocarps	OGS or top soil Top soil + sand	Polyethylene bags	Jacalne, 1981 Kijkar, 1990
Balsa	Sandy loam strained in 1/4 mesh wire	4"x6", 6"x9" plastic bags	
Most forest tree and fruit tree species	Top soil + thoroughly pulverized animal manure (2:1) or top soil + sand (6:1) + compost (1-3 parts) or 2-4 heaped tablespoonful of complete fertilizer/5 gallon/can soil	Paper pots	Manila Seedling Bank

- In Thailand, coconut husk/coir as a nursery planting medium in comparison with other media (i.e. soil, sand and mixture of soil and coconut husk, sand and coconut husk, soil and sand, and soil, sand and coconut husk at proportion of 1:1) for the preparation of Narra seedlings was thoroughly studied. It was found that coconut coir has significant advantage over other media/mixture particularly if osmocote (slow-release fertilizer) is added.

- Growth and development were comparatively much better. Other advantages of coconut husk are:

a. Light weight, minimizing transportation cost.

b. High water holding capacity, minimizing watering cost and time.

c. Adhesivity is high. After germination, fibrous root system development penetrates much easier and binds the coconut husk more tightly. This makes easy lifting of the seedling from the container with the ball of husk unbroken. This property enables possibility to transport bare-root seedlings more effectively.

d. Porosity of the materials enables root system to develop vigorously thus seedlings have high survival.

- Organic material like sawdust and coconut husk/coir dust if used fresh, however, may cause some unfavorable effects to seedlings. They will undergo decomposition and may increase temperature and acidity.

- Most serious constraint in using coconut husk is the termite attack. It has been observed at the Asean Canada Forest Tree Seed Center in Thailand that seedlings are damaged by termites searching for water during dry season and organic matter for their diet.

- The problem however can be overcome by enhancing the decomposition/breakdown of organic materials. Specifically, the decomposition of sawdust and coconut can be stimulated by applying certain strain of microorganism (*Trichoderma viride*). It was found that two weeks after application, the sawdust can be used for potting medium.

- Coconut husk/coir dust 60 days after stimulating decomposition through application of microorganism, can already be used as potting medium.

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NURSERY CULTURAL MANAGEMENT

Wilfredo M. Carandang

CONTAINERIZED OR POTTED STOCKS PRODUCTION SYSTEM

Sowing

- Small seeded species are sown in germination trays or seedboxes while large ones make use of the seedbeds.
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- Germination trays are normally made of plastic, metal or wood. Once the trays are filled to within 4 to 6 cm from the rim, the medium is smoothed and lightly tamped.
- Seeds are then placed on the prepared medium then covered with 6 to 10 mm of rice hulls, chaff or sterilized sand. Such coverings allow better seedling emergence than pure soil and even protect the seeds from animals.
- Sowing deeper than 6 to 10 mm below the surface sometimes prevents emergence.
- For small seeds special sowing techniques may be employed, like the use of a moistened needle or a sieve.
- Seeds on seedbeds may be sown in furrows or lines "head-to-tail" or end-to-end.
- Large seeds with wings have to be de-winged first then laid flat on the beds.

- It is not advisable to push the seedlings down as this may cause the formation of J-roots.

- Seeded trays are placed under 20 to 50 percent shade and watered as needed.

- Artificial shades on the one hand are provided in seedbeds immediately after the sowing operation. Shading methods for small nurseries are simple or complex, using metal frames, wooden T-frames, palm fronds, nets, woven bamboo slats and other indigenous materials.

- Overwatering must be avoided after sowing to prevent the occurrence of damping-off.

- A simple test to determine if moisture in the soil is adequate is to squeeze a small portion of the soil between the thumb and forefinger. If water can be squeezed out, no additional watering is needed.

Tending Operations

A. Transplanting

- Transplanting is done when the seedlings are large enough to be handled safely but before they get too large and crowded in seedboxes and seedbeds.

- In the case of pines, the optimum time is 3 to 6 days after emergence and before the seed coat is shed off.

- For *Anthocephalus* spp. and *Eucalyptus* species, the seedlings must be at least 2 cm tall or have four or more leaves that are large enough to handle.

- In most hardwoods, transplanting is normally done when the seedlings are sufficiently lignified.

- Early lifting after germination serves two purposes. First, seedlings are lifted before tap roots develop lateral branches. If lateral roots are stripped off older plants, lost water absorption capacity causes wilting and even death. Second, large root systems are easily bent during transplanting, causing the development of J-roots.

- Transplanting into lined-out pots has two advantages over direct seeding into pots. First, managers do not have to wait several weeks to see if seedling density is satisfactory; workers control density in lined-out pots by transplanting one healthy seedling in each pot. Second, once seedlings are ready for lifting, transplanting can be staggered over several weeks or days. This procedure allows grouping transplants by similar age classes so that outplanting is also spread over a longer period.

- The roots of seedlings must be kept moist throughout the transplanting process to avoid desiccation and heat.

- The dibble method is commonly used in transplanting operations (potting). One laborer can transplant about 4,000 seedlings per day; two working in pair can even finish up to 10,000 plants in a day.

B. Resowing

- Resowing is done on blank spaces in the seedboxes and seedbeds where germination has visibly failed.

- It is important to note that when there is at least 20% failure in germination, the seedlot has to be thoroughly re-examined in terms of quality and discarded.

- A different pre-germination treatment may be prescribed in seeds with known dormancy.

- Resowing should be done as soon as failure is detected.

- Delays in resowing operations may mean drastic differences in size of plants within the seedbed or seedbox such that the older germinants may suppress the younger ones.

C. Watering

- Seedbeds should be kept moist but never saturated with water.

- Seedboxes/seed trays should be checked two to three times a day.

- As a good guide, if the medium is moist to fingers but water cannot be extracted by squeezing, moisture is considered to be adequate (Fishwick, 1966).

- Germination beds or boxes should be watered in fine mist to prevent washing off of seeds.

- When overwatering occurs, shade should be temporarily removed to speed up evaporation.

D. Shading

- Transplanted seedlings should be placed under at least 30% shade for 1 to 2 weeks after the transplanting operations.

- Seedbeds can have 20 to 30% shade cover for the first month.

- In open and sunny areas, the shade is then gradually removed as seedlings become older as a form of initiating the hardening-off process.
- To avoid edge effects by exposure to sunlight, shade materials are normally extended 0.3 to 0.5 meter beyond the bed borders.

- Early in the day, sunrays are best blocked by dropping screens at ends of the beds.

- In the tropics, in most cases, greater shade extension is needed on the south side of nursery beds than on the north side (Mc Donald, 1984).

E. Weeding

- Only maintenance weeding is needed in the early weeks after transplanting and direct seeding in pots.

- Hand weeding is fairly common in the tropics.

- The weeding frequency depends on the degree of sterilization of the medium, the extent of viable seed weed in the medium used and the presence of nearby weed and grass seed sources.

- Weeds must be pulled when they are small, young, and succulent, before their root systems develop too much.

- Weeding is normally preceded by watering to make the soil soft which may facilitate the operation.

F. Grouping, Sizing and Lining-out

- Nursery seedlings should ideally be uniform in size and foliage characteristics as well as in extent of their roots.

- In container systems such may be attained by grouping and sorting the seedlings according to height and/or diameter of stems.

- Potted seedlings can be lined out on the ground or other surfaces and in permanent raised or sunken beds.

- Raising pots on blocks and wire screens fosters root pruning.

- When containers are placed on hard surfaces or on plastic sheeting, root egress is adequately prevented making seedling processing later on an easy job.

G. Shoot and Root Growth Control

- In containerized systems, shoot growth can be controlled by grouping seedlings of similar height in the same potbeds.

- This practice keeps fast-growing seedlings from shading out the slow growing ones.

- If overtopping cannot be adequately controlled by regrouping, fastest growing individuals can be clipped back.

- In addition to slowing the top growth, such an operation may also enhance the expansion of the root system. As such there must be sufficient pot volume to accommodate the perceived root growth or else root spiraling may occur.

- Root growth of potted seedlings may be controlled by effective pot volume and depth. Once the roots fill this volume and reach the pot bottom, seedlings must be outplanted.

- Extra holding time may mean root spiraling and strangling.

- It is imperative to know the seedling shoot and root growth rates as well as the outplanting dates whenever selecting for optimum pot volume.

- With unforeseen delay in outplanting, seedling may be repotted in larger containers or severe root pruning may be done.

H. Lifting and Transporting

- Root systems of containerized plants are self-contained and protected.

- Fewer precautions are needed in lifting and transporting potted stocks than those that are needed for bareroot stocks.

- If the roots have grown through the pot bottoms, they must be pruned and trimmed before loading.

- Containers are normally placed in transport flats, loaded onto trucks and securely tied.

- Trucks are usually covered during seedling transport to prevent wind-burn.

- Usually a 5- to 8-cm head space between each layer of seedlings is allowed in truck beds.

- For safety reasons, when the potting medium used is soil, fewer tiers should be accommodated so as not to create a top heavy condition.

- The following are the stock assessment practices in the Philippines as practiced by different corporations and institutions:

1. *Paper Industries Corporation of the Philippines (PICOP Resources, Inc.)*

⇒ morphological grading system
⇒ earlier system made use of five morphological grades: A1, A2, B1, B2, C and D
⇒ current system has established standards primarily for height with accompanying production time standards

SPECIES	Height Standard (cm)	Production Time (days)
Paraserianthes falcataria	10	45
Eucalyptus deglupta	10	90
Pinus caribaea		120
Acacia mangium	35	45
Gmelina arborea	20	

2. *Philippine Forestry Development Project in Ilocos Norte (PFDPIN)* (Visco, personal communication)

⇒ plantable seedlings are 25 cm and above
⇒ Species: *Eucalyptus camaldulensis*
Acacia mangium
Acacia auriculiformis

3. *Bukidnon Forest Incorporated (BFI, 1994)*

SPECIES	HEIGHT (cm)	DIAMETER (mm)	AGE (wk/mo)
Gmelina arborea	> 20	> 3	10/2.5
Swietennia macrophylla	> 20	> 3	20/5
Eucalyptus spp.	> 20	> 3	13/3
Acacia mangium	> 20	> 3	13/3
Pinus spp.	> 20	> 3	20/5

4. *Forest Management Bureau (FMB) of the Department of Environment and Natural Resources (ACFTSC, 1990)*

SPECIES	TOP/ROOT RATIO (cm/cm)	DIAMETER (mm)	HEIGHT (cm)	AGE (months)
Paraserianthes falcataria	1.05:1	1.2	10-20	1.5
Eucalyptus deglupta	2.02:1	3.8	20-30	3.0
Pinus caribaea	1:1	5.0	> 25	4-5
Acacia mangium	2.62:1	3.7	20-30	2.5

5. *RP-Japan Forestry Development Project (1987)*

⇒ grading made use of height and basal diameter with corresponding sowing synchronization time standards.

SPECIES	HEIGHT (cm)	DIAMETER (mm)	AGE (mo)
Acacia auriculiformis	25-40	2.0	3-4
Anisoptera thurifera	30	7.0	
Eucalyptus camaldulensis	30	2.0	
Gmelina arborea	30	7.0	6-7
Swietennia macrophylla	50		8
Vitex parviflora	30	7.0	7-8

6. *ASEAN-New Zealand Afforestation Project (ANZAP) (Schroeder and Thomson, 1987)*

⇒ General Practice

Containerized seedlings:

Height:	25-35 cm
Diameter:	4 mm

Bareroot Seedlings:

Root:shoot dry weight: 0.4
Stem height: Diameter Ratio: 50:1

⇒ Seedling grades:

1	-	< 25 cm tall
2	-	> 25 cm tall, < 4 mm diameter
3	-	> 25 cm tall, > 4 mm diameter

BAREROOT PRODUCTION SYSTEMS

- Bareroot nursery stock is produced by traditional labor intensive and mechanized methods. Species successfully grown by the bareroot system are mostly pines, teak, Gmelina, Casuarina, and Kaatoan bangkal (*Anthocephalus chinensis*).

Some of the advantages of this production system are:

a) Sowing seeds directly on ground level or raised beds avoids transplanting after germination

b) Early and later tending care are usually easier

c) There is less weight to transport from nursery to the planting site, allowing more seedlings to be carried per trip

d) Easy bundling, seedling handling and processing

e) Bareroots are the best type of planting stocks for mechanized planting.

The disadvantages are:

a) Nursery soils need inherently good physical and chemical properties for permanent use

b) Seedlings need 2 to 3 months more time for development

c) Damage is potentially greater to roots during seedling processing, handling and transport

d) Large amounts of high quality irrigation water are normally required

A. Seedbed Preparation

- The seedbeds in the tropics should normally be oriented following the east-west direction, that is, the individual beds should be aligned in the poleward direction. With an east-west orientation, the seedbeds are usually fully exposed to the sun during the middle part of the day. Such extreme exposure may be corrected by appropriate shading.

- Cover crops may also be grown on the production beds during the off-production or fallow period.

- Legumes are primarily considered for such due to their ability to fix atmospheric nitrogen, hence, they can ameliorate the nitrogen conditions in the soil. Cover crops may also protect the land from erosion.

- Bed areas that have been in fallow should be plowed 4 to 6 months before the sowing operations to allow sufficient decomposition of the materials which reduces soil C/N levels to that which does not limit seedling nutrition.

- A C/N ratio of 30:1 or less avoids adding supplemental N fertilizers.

- Beds are normally cultivated manually or with the aid of work animals (e.g. carabao in the Philippines) or with a small tractor.

- Hand cultivation is limited to beds 5 m or shorter.

- Standard beds are 1.2 meters wide, with seven seedling rows. Mounding within the beds may be done to increase aeration and enhance drainage.
- Footpaths should be at least 45 cm wide between the beds to allow easy access for weeding and other activities.

B. Sowing

- Furrows are normally dug along strips and stake guides.

- Seeds are covered to a depth of up to twice their width.

- In mechanized operations, there are push-type planters or seeders that can drill seeds and fertilizers to specified depth at the same time and cover such in a single operation.

- Fertilizers may be placed alongside or underneath the seeds, with an intervening layer of soil in between.

- For small seeded species, the seeds are broadcasted by hand or mechanically with implements such as the cyclone broadcast seeders.

C. Tending Operations

1. Mulching

- To protect the newly sown seeds from extreme exposure to the sun and/or to conserve soil moisture, mulching is done using organic materials free from seed or root weeds that are locally available. Such materials should not hamper the germination process, hence, an appropriate amount of materials should be determined so as not to weigh down the sprouts.

2. Watering

- Bareroot seedlings are more generally exposed to air and light than containerized stocks. Thus the water needs of this type of nursery stock are normally greater.

- Nursery beds should be checked frequently for moisture and for signs of wilting.

- Actual water needs may vary by site, and are normally related with soil texture, climatic conditions in the area, species as far as transpiration rate is concerned, and the growth stage of the seedlings.

- Approximately 100 liters of water are needed daily by a bareroot bed 1.2 x 5 meters in size (Mc Donald, 1984).

- For medium to large bareroot nurseries, fixed irrigation systems gives best water coverage for as long as there is an abundant water supply.

- For small nurseries, water hoses or sprinkling cans may be used. It should be remembered that water should be applied in fine droplets.

3. Weeding

- The open feature of bareroot beds favors more weed growth than do container beds.

- Hand weeding is normally resorted to in the tropics. For large nurseries, herbicides may be used. But extreme care should be exercised in the selection, application and storage of such chemicals.

4. Shoot and Root Growth Control

- Undercutting, lateral pruning, and top pruning are techniques to control root and shoot growth of bareroot stocks.

- Root wrenching is practical only in large, mechanized nurseries.

- Undercutting is usually done with sharp shovels and with large tractor-drawn machines in large nurseries.

- Clean severing of taproots stimulates lateral root growth but stops shoot growth. Lateral root pruning severes roots between adjacent seedling rows.

- The technique allows easier lifting of seedlings before packing and transporting.

- Top pruning (clipping or trimming) controls excessive shoot growth.

- The technique is used selectively for individual seedlings that are overtopping others and for entire beds when all seedlings have grown too fast and must be kept longer before lifting. The operation stimulates root growth.

- Hand shears are used for small nurseries and tractor-drawn mowers in large ones.

5. Lifting and Transporting

- Lifting, protecting, grading and transporting comprise the seedling processing and handling in bareroot nursery stocks.

- Stocks should be lifted with shovels, never pulled directly from the soil; the latter can strip rootlets from seedlings particularly if they are pulled from dry clay soil.

- Soil is shaken off the roots, which are immediately washed, trimmed, and then stored in water, or water slurries.

6. Grading

- Grading separates plantable from culled seedlings.
- Grading standards vary by species and geographical area but usually include height, stem diameter, shoot/root ratios, foliage condition and root mass.
- Side leaves may be stripped to minimize water loss through transpiration. Only large, well-developed seedlings should be planted.
- Mud puddling is recommended to provide protection to the bareroot planting stocks.
- Planting within a few hours after lifting, or at least the same day as lifting is necessary.
- If transporting and planting delays cannot be avoided, do not lift the seedlings.
- Heeling-in may be done when planting of bareroots is delayed.
- Seedlings should be kept cool, in the shade and moist at all times after lifting and during transport.

Q. Hardening off

- Seedlings are given the best of environments in the nursery which is not essentially the same environment that they will have once outplanted. As such nursery seedlings should gradually be conditioned to the harsh/adverse environment that they will encounter when they are field planted. Such process of conditioning is called hardening off.

- When seedlings are grown in the nursery over short periods of time, water, fertilizer and shade are used to stimulate rapid growth. Such forced growth regimes, however, usually produce succulent seedlings that do not survive harsh conditions normally prevailing in the planting sites.

- The hardening off process actually increases the probability that the seedlings will survive the outplanting shock.

- The process conditions both containerized and bareroot seedling stocks to survive without water and shade as long as possible in the nursery before they are outplanted.

- Shading may be removed gradually as a process of hardening-off.

- At the start, shade should be removed gradually for 2 hours during the day (1 hour in the morning and another hour in the afternoon).

- After 3 or 4 days, the length of the shading period is reduced another 1 to 2 hours. By extending shade-free time gradually, seedlings will be able to tolerate sunlight with a minimum shock within 2 to 3 weeks.

- Hardening-off may also involve the reduction of water made available to seedlings. This may be done by gradually extending the time between watering periods by 2 or 3 days.

- The number of waterless days is progressively extended until seedlings are capable of surviving up to 2 weeks or longer without water. However, in the process wilting should be avoided. If it does occur, watering may be continued until the plant recovers; then water reduction begins again but at less severe regimes.
- In container beds, hardening-off should be done with careful consideration of the relationships between pot volume, potting medium, and seedling size.

- It should be noted that older seedlings will transpire relatively large amounts of water from small containers filled with porous medium.

- Nursery managers should observe and carefully record all information related to watering, wilting, and seedling densities in beds. When information is properly assessed, nursery beds can be efficiently managed with little loss due to improper hardening-off.

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ESTBLISHING AND MANAGING ON-FARM AGROFORESTRY NURSERY

Armando M. Palijon

INTRODUCTION

- Agroforestry farmers certainly will need high quality planting stocks for the development of a sustainably productive agroforestry farm.

- Sources of the required planting stocks normally are purchased from commercial suppliers. Some are provided by government or NGOs either free of charge or at cost. Since these sources are located far from the community, handling and transport are not only costly and difficult but also sometimes damaging to the seedlings.

- Making them self-reliant, agroforestry farmers and associations, have to produce their own needs and requirements. There are two levels of on-farm agroforestry nurseries. One is community or association nursery and the other is individual home nursery.

OBJECTIVES

- On-farm AF nursery is not only aimed at producing high quality planting stocks enough for farmers' own needs.

- It will also endeavor to produce planting stocks that are in demand or have market for generating income. This will make nursery operations self-sustaining. It will likewise become additional source of income for the AF farmers.

- The nursery will serve as important training facility for AF farmers including women, children and youth from within and outside the community.

- This will likewise be a venue for AF farmers' cross visits, productive interactions and sharing of experiences.

Basic Guidelines

- Site selection

- ♦ Biophysical and technical considerations like topography, vegetative cover, soil, water supply and others which were discussed previously in this manual are also important in selecting site for on-farm AF nursery.

- ♦ The community's or association's on-farm AF nursery must really be located strategically in the area. It must be easily accessible to all AF farmers. Preferably, the land should be public or communal property.

- ♦ Individual home nurseries is naturally have to be established at AF farmers backyard or home premises.

- Establishment

- ♦ Community's or association's on-farm nursery has to be established through the concerted efforts of all AF farmers and other community members.

- ♦ Facilities like building/bunkhouse, soil and potting shed, composting pen and water system that are necessary for the efficient nursery operations must be installed.

- Locally available materials for the construction of the nursery facilities can be procured from communally owned property. Individual AF farmers must be encouraged to contribute construction materials available from their own farms.

- Tools and equipment like wheelbarrows, spades, shovels, hoes, pruning shears, grafting and budding knives must be made available in the nursery. If funds are limited, members can pool their resources. Those who have tools of their own should volunteer to donate or lend them, if only to start the nursery operation.

- Similarly, the nursery must be laid out to include nursery beds (seed bed, recovery pot beds and hardening beds). The size should also follow the standard for nursery beds. Once the nursery has been built, schemes to make the nursery operational must be planned by the AF farmer members themselves.

- Nursery Propagation and Cultural Practices

- Two types of planting materials can be produced from the on-farm agroforestry nursery. These are seedlings and vegetatively propagated stocks. Choice of species may be based on the needs and preferences of the farmers, suitability to the site, market demand and supply, and others.

- Collection or procurement of propagules can be done in many ways. The association can purchase from certified seed dealers or request from concerned government institutions like the DA-BPI, DENR-ERDB, UPLB College of Forestry and Natural Resources, and from NGOs and other development organizations.

- AF farmers should develop an attitude of collecting seeds wherever they go and visit. Individual collection will considerably meet the need for propagating materials of the nursery. Collected seeds of fruit trees, for example, can be germinated and raised as stocks for grafting and budding purposes.

- Seeds, scions and clones from mother trees of proven quality can likewise be produced through exchange with other AF farming communities. These materials can also be collected from the farms of the community or association members.

- Seed technology, procedures in propagation and nursery cultural practices presented in this manual shall be followed to ensure production of quality stocks.

- Management of on-farm nursery

- It is recognized that the community or association has its own set of officers. This does not mean that they are the ones who will manage the nursery.

- Nursery establishment and management aimed at producing planting stock for the community could be only one of the many projects the community can have.

- Thus, it is only logical that management of the projects be distributed to qualified members. In such case, a nursery manager may be selected from among the AF farmer members who have the time, willingness, commitment and dedication and more importantly the technical as well as management skills.

- The nursery manager, through participatory approach , will develop the plan, set the goal, and provide direction for smooth and efficient operation in the nursery.

- All the AF farmer members and their families are considered potential manpower for the nursery. Schemes to systematize the schedule of the members in accordance with the planned activities need to be properly defined in order to ensure full cooperation and participation of everybody.

- Equal share for equal work should apply in order to maintain harmony. Regular monitoring therefore of the quantity and quality of participation and contribution of each member is necessary. This must be basis for the distribution of shares not only of planting stocks but also income to members.

- To improve management of the nursery, qualified members should be sent to trainings and cross-farm visits.