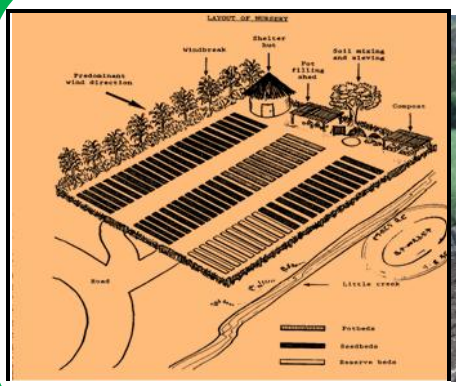
# GUIDLINE FOR PRODUCTION AND MANAGEMENT OF PLANTING MATERIALS FOR WATERSHED DEVELOPMENT

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# MODULE 1: INTRODUCTION

Timely and sufficient supply of planting material is one of the major bottlenecks for successful watershed rehabilitation as biological measures ensure the sustainable stabilization of physical conservation measures. The problem is specifically acute for grasses, which are required in large quantities and planted on all land-use types. At present, this limitation is resulting in delays of the completion of watershed development activities in the majority of SLM watersheds under rehabilitation.

In order to properly address the demand for planting material, the establishment of nurseries is mandatory. Nurseries are a key success factor for watershed development. A nursery site is a properly managed site, designed to produce tree or grass splits grown under favourable conditions until they are ready for transplanting. Nurseries vary in size, facilities (supplies, tools, equipment, etc.), types and amount of seedlings they produce and longevity. For instance, individual or family-run nurseries typically produced from 50 to several thousand seedlings/season. Large woreda or government nurseries produce 1,000,000 seedlings/season or more.

As a rule of thumb for a micro-watershed having an area of 500 hectares, 0.7 million tree seedlings, one million grass splits/cuttings and 70 kg of leguminous shrubs are needed. So for an average critical watershed with 10-15 micro-watersheds very high amounts of planting material are needed, and the production of this material has to be planned very properly at woreda, CWS and MWS level.This should be done between six months to one year ahead of the time at which the planting material isrequired.

In addition to their function of multiplying planting materials, nurseries can also provide income generating opportunities for the operators and enhance the social capital, technical capacity and leadership skills of communities. Nurseries serve as important training ground for many smallholder farmers. Exposure of farmers to central woreda nurseries helps smallholder farmers to develop capabilities and the confidence to improve and conserve their landholdings through small-scale tree nursing.

This technical manual was prepared to provide guidance for regional experts, woreda experts and development agents so that they properly plan and implement the multiplication of adequate quantity and quality of planting materials.

## 1.1 Type of nurseries

Nurseries vary in their capacity of producing seedlings. It varies from a few dozens of seedlings grown by individual farmers to producing millions of seedlings per year by central Woreda nurseries. Nurseries can be classified based on life span and ownership. Based on life span, nurseries can be either permanent or temporary. Based on ownership nurseries can be private (individual), self-help group or community, Institute and central (Woreda). In Ethiopia and in the context of SLMP planning framework, nurseries are classified based on ownership.

### 1. 1.1 Central (Woreda) nursery

Central or Woreda nurseries are established and operated by Woreda office of agriculture and are established to provide quality seedlings and grass splits to communities and farmers. They are designed to operate for a longer period of time .The production capacity of those nurseries is dictated by government targets and usually can reach millions of seedlings/splits. They may also serve as sources of seeds and seedlings for smallholder nursery operators (individual and group nurseries). Government (central) nurseries have access to technical information and resources produced by research institutions and different donors. Hence, they have better capacity to offer technical training for the target community and catalyse group, Institute and individual nursery development. They are excellent in strengthening the technical and leadership skills required by communities.

The seedling production process in central nurseries is not market-driven and is rarely commercially-oriented, though sometimes a nominal fee is charged to ensure seedlings are valued by the community. Central nurseries operations depend on government budget allocations. Donor funded projects (e.g., SLMP) usually supports government nurseries by allocation of budget for purchasing of seeds, equipment's and other facilities.

**Project supported government nurseries** can be established below woreda level. The intended lifespan of those nurseries is usually 5-7 years, but may continue for longer periods depending on lifespan of projects. Production capacity varies from 100,000 seedlings up to a million per year.The objective of establishing nurseries below woreda level is to produce a seedlings production system that allow the project to control the quality and number of seedlings produced and to improve access of seedling produced. The obvious problem with centralised nurseries which are located at woreda level is seedling distribution and limited capacity to produce adequate seedlings. In many projects, the average distance between the central nursery and project sites is twenty or more kilometres, and sometimes much further. Even though, the problem can be alleviated by transporting seedlings to villages, schools and other collection points, this is only possible if vehicles are available at planting time. Even then, there can be problems for Lorries and pick-up trucks attempting to use bad rural roads during the rainy season.

### 1.1.2 Community/ Self-help group Nursery

Community/ Self-help established & owned by community groups or highly supported by the project **as a replica of central nurseries** satisfying demand of the project that could supplement capacity of central nurseries where planting sites are very far from central nurseries. Technical and logistic support is provided from the project/government and should be linked with central nurseries. Establishment of those nurseries helps to minimize problems of loss of seedling due to transportation, human resource shortage and may provide diversified seedling species based on demand of the community.
Group/community nurseries are also need and trust based establishments whose processing and procedural performance would be performed with the intensive support of concerned and/or respective professionals. It is established to impart seedling propagation and nursery management skills to target participants, for the specific purpose of providing tree seedlings or grass splits to meet local needs, at the same time it serves as an income generation activity. Group size is usually 10 to 25 individuals. But, it is to be determined on the basis of the holding capacity of the land allotted for nursery.

Predominantly, life span of self-help group nurseries is based on: first, if revolving fund group, for a minimum of one year and maximum of approximately five to seven years (upon evaluated graduation). Even after five to seven years, other jobless youth or women will again be organized anew.

At the local level, particularly in remote areas, group and individual nurseries are often the main source of tree seedlings and thus key supporters of reforestation, tree planting and vegetative stabilization activities. In many cases, group nurseries sell seedlings or grasses to project supported government agencies implementing reforestation or biological conservation activities based on contract.

Self-help nurseries approximately produce up to 100,000 seedlings. In Oromia regional state Self-help group nurseries have the capacity to produce up 2 million seedlings. Nursery sizes may vary depending on their location. Small self-help group nurseries may be operated by as few as 2 to 3 neighbouring households, while the bigger nurseries are operated by groups specifically organized for such responsibilities. Both men and women have roles to play in group nurseries, from decision-making through work plan implementation. The smaller group nurseries tend to have a longer lifespan because collaboration is often based on relationships of family, friends and trust. Larger group

nurseries tend to stop operating when objectives are met or external support is terminated. In exceptional cases, when some members are willing to continue with their own resource it may continue to operate.
In group nurseries, members are required to nominate their management committee keeping their group formulated bye-law into consideration. The number of management committee members is five (chairperson, secretary, cashbox holder and two observers). In Oromia, standardized cashbox is favoured by beneficiary farmers and very luckily served as an energizer. The work subgroup is expected to be categorized by the management committee. The committee directs them in planning, scheduling and programing, as well.

### 1.1.3 Private/Individual nurseries

Private or Individual nurseries are also known as household nurseries or backyard nurseries and are generally established and managed by individual farmers and/or their families. These nurseries are usually initiated to produce seedlings or grass splits for planting on operators' personal farms. The house compound and farmlands are used as the planting sites. The size, production capacity and level of sophistication varies widely; from a few seedlings grown bare rooted, to well-fenced nurseries of a few hundred seeds, to a thousand seedlings grown in polyethylene bags.

Although private nurseries are generally established to meet a family's need for tree seedlings or grass splits/cuttings, they may also generate income through seedling/grass splits sales. Even more than group nurseries, some private nurseries evolve towards market-orientation. Some individual nurseries become exclusively commercial enterprises and provide significant income to owner-operator (e.g. Farmers raising Apple seedling in Chencha, SNNPR: Farmers involved on multiplication and sale of Desho Grass and Vetiver in SNNPR and Oromia: farmers involved in raising and sale of Gesho in Tigray). This is particularly true in areas with a strong market demand for tree seedlings and grass splits. Networks of individual nurseries may form to respond to these market opportunities.

Due to their limited size and facilities, individual nurseries are generally not used for formal training. However, they can provide effective farmer to-farmer training activities. These trainings are informal and provide farmer nursery operators and visiting farmer’s ample opportunities to exchange ideas and experiences. Discussions are usually focused on very practical and effective topics, procedures, and technologies. Extension agents and technicians can also learn about small-scale nursery technologies by visiting successful individual nurseries.

Private nurseries largely depend on family resources. However, Government/projects may provide technical and material assistance to operators, particularly during nursery establishment. This assistance usually focuses on providing good quality seed, training on tree propagation and nursery management and assistance on equipment’s such as water cans, hoes, spades and rakes. Commercial-oriented individual nurseries evolve as self-funded through seedling sales and the provision of technical services. In SLMP context a minimum of 8000 seedlings per year is expected from private owners; to be considered as a private nursery.

### 1.1.4 Institutional nurseries

Intuitional nurseries in Ethiopia are mainly school nurseries and nurseries established at Farmers training centers (FTCs), Churches and mosques. The capacity of those nurseries can vary between 1000-5,000 seedlings per year. Integration of the nurseries with schools and Farmers training centers can significantly contribute to teaching of students and farmers on seedling preparation and tree-planting techniques. Kebele level institutions (Schools and Farmers training centers) can also play a role in multiplying and supplying seedlings to watershed development. Also churches have experience of producing, planting and protecting forests for natural regeneration of indigenous trees.

## 1.2 Nursery linkage

During their establishment phase and the first few years of operation, most group nurseries and many individual nurseries receive financial and material support. This support is primarily provided by central nurseries and Woreda office of agriculture. The funds for support of local nursery development are usually provided by the projects and external donors. This support can facilitate networking between the different nurseries, which can have a great impact on nursery performance.

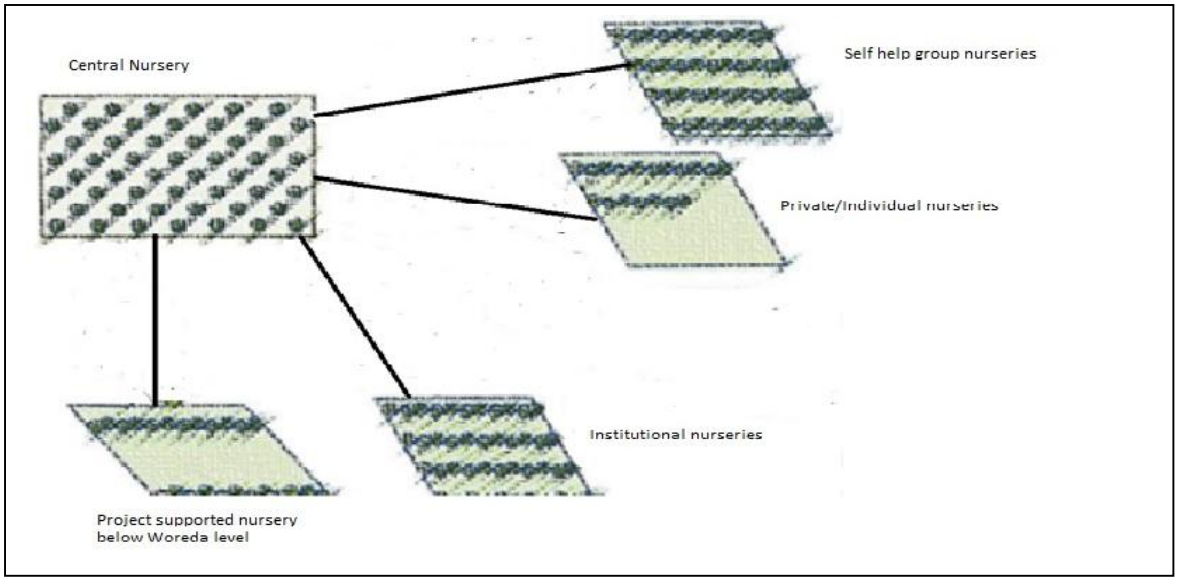


Figure 1: Nursery linkage

### 1.2.1 Selecting a nursery type

It should be noted that there is rarely a single 'best' nursery type for any given situation; any number of types often serve the need. However, to maximize the chance of success, the criteria presented below should be considered before selecting a nursery type.

**Table 1: Selection Criteria for Nursery Types**

| Criteria | Nursery type | | | |
|---|---|---|---|---|
| | **Central** | **Community /Self -help Group** | **Private/Individual** | **Institutional** |
| **Objective and function** | | | | |
| Technology dissemination | High | High | Low | High |
| Capacity building | High | Medium | Medium | High |
| Income generation | Low | High | High | Low |
| Appropriateness' for farmer to farmer extension | Low | High | High | Medium |
| **Operation features** | | | | |
| Production capacity | High | Medium to High | Low | Low |
| Duration of operation | High | Low to High | Low | Low |
| Quality of seedlings | High | High | Low | Medium |
| Species diversity | High | High | Low | Low |
| Proximity to planting site | Low | High | High | High |
| Access to information and research | High | Low | Low | Medium to High |
| Difficulty in coordination | High | High | Low | High |
| Permanent supply | High | Low | Low | Low |
| Challenges for seedling distribution | High | Low | Low | low |

## 1.3 Possible number of nurseries per major watershed

### A. Assumptions

1. Number of kebele's in one critical watersheds =5
2. Number of micro-watersheds per critical watersheds=12
3. Number of micro-watersheds planned to be fully rehabilitated per year=3
4. Number of schools and FTC per kebele =2
5. Planting material demand for three micro-watersheds

**Table 2: Assumptions for Possible Number of Nurseries per Major Watershed**

| Type | Demand per micro watershed (refer Table 3 below) | Demand for three Micro-watersheds |
|---|---|---|
| Grass splits | 750,000 splits | 2,250,000 splits |
| Grass cuttings | 320,000 cuttings | 960,000 cuttings |
| Seedlings | 661,669 seedlings | 1,985,007 seedlings |
| Forage seed | 72. 5 kilogram | 217.50 kilogram |

6. Production Capacity of different nurseries

**Table 3: Production Capacity of per category of Nurseries**

| Nursery types | Production capacity | | |
|---|---|---|---|
| | Seedlings | Splits | Cuttings |
| Central nursery | 700,000 | 700,000 | 500,000 |
| Project supported nursery at kebele level | 700,000 | 700,000 | 500,000 |
| Self-help group /community nursey | 50,000-100,000 | 100,000 | |
| Institutional nursery | 5000 | | |
| Private nursery | 8,000 | 30,000 | |

### B. Possible number of nurseries required per major watershed

**Table 4: Possible Number of Nurseries required per major watersheds**

| No. | Nursery types | Number of nurseries |
|---|---|---|
| **1** | Central nursery | 1 |
| **2** | Project supported nursery at kebele level | 1 |
| **3** | Self-help group/community nursery | 5-10 |
| **4** | Institutional nursery | 5 |
| **5** | Private nursery | 10 |

# MODULE 2: NURSERY ESTABLISHMENT

## 2.1 Nursery site selection

Before establishing a new nursery, we have to know whether the existing nurseries are able to satisfy the demand for seedlings in the locality. Nursery site is selected in an area where there has not been any nursery or an area where the existing one(s) are not able to satisfy the demands. The main criteria for selecting suitable nursery site are discussed as follows:

### 2.1.1 Suitable altitude

Altitude (due to its associated rainfall and temperature changes) has the greatest effect on the growth of trees shrubs and grasses. Similarly, altitude affects the growth of seedlings and grasses in the nursery. The lower the altitude and the warmer the nursery site, the quicker the seedlings grow and the sooner they are ready for planting.

It is not advisable to grow seedlings that will be used in a highland plantation at a low land nursery site. Seedlings should adapt to the prevailing climate in the future plantation site and this happens best if the nursery is at approximately the same altitude as the plantation site. A good compromise is to establish the nursery in the nearest corner of the project site.

### 2.1.2Availability of land

It is important that at the site chosen for the nursery, there should be enough land to raise the number of seedlings and grass splits and if possible room for expansion. The site should be big enough to include 20 per cent (20%) extra for losses and damage in addition to paths between the beds, soil storage, thatched shelter and compost- making area. The size of the nursery depends on the number of plants to be produced, the time they will remain in the nursery, as well as the quality and slope of the site.

It is important to ascertain who owns the land and formalize the use of the land by obtaining a letter from the owner, government or private, agreeing to its use as a tree nursery for a defined period of time.

Finally, it is important that the nursery will not cause problems for others, for example from the shadow a tree will cast or by decreasing crop yields through competition for water. It may be necessary to consult communities in order to avoid conflicts.

### 2.1.3 Water supply

A reliable and adequate water supply is a requisite in nursery establishment. The nursery site should be located near a source of water either from a running stream or main pipe water supply to sustain rapid and healthy growth of the seedlings. The ideal situation is where there is a perennial stream at a higher level than the nursery, and fairly close to it, so that water can be diverted from the stream to the. Alternatively, a water storage tank should be installed for sustainable water supply. On average 10 to 20 litre per square metre of seedling bed is needed per day.

### 2.1.4 Topography

Relatively flat land, ideally with a 2-5% slope, is most suitable for a nursery site. This permits water to run off so that water logging does not create a problem. Completely flat land should be avoided to prevent from water logging during heavy rains. Otherwise good drainage system should be constructed. Avoid very steep slopes, to prevent erosion. If flat land is not available, terraces must be constructed. Average slopes should be terraced wide enough to accommodate a normal nursery bed of a meter in width, plus paths on each side to allow access to the beds.

### 2.1.5 Accessibility to the plantation site

The seedling transport is usually done during the rainy season. So the nursery site should have an access road and whenever the nursery is nearer to the plantation site the transport cost can be minimized.

### 2.1.6. Infrastructure

A nursery should have an all-weather road that provides access right to the site. If possible, there should be truck access into the nursery itself so that materials can be efficiently delivered and seedlings easily loaded onto trucks with minimal labour inputs. It is most desirable to have a good road system that leads from the nursery to the plantation sites so that at planting time it is possible to quickly and efficiently transport seedlings from the nursery.

### 2.1.7 Availability of suitable soil

In nursery where plants are to be raised in poly bags, large quantity of sandy loam or loam soil with well drain property, preferably forest top soil will be required. But if we have only heavy soils like clay, then sand mixture is also required.

For bare root nursery, a deep, good-structured, easily pulverized soil is desirable. Avoid shallow soils with a hard sandstone band near the surface. A very sandy-structured soil should also be avoided because of poor moisture retention characteristics and faster leaching of plant nutrients. Soil containing too much clay has poor drainage characteristics and should not be considered in site selection.

### 2.1.8 Sheltered location

A nursery site should not be exposed to desiccating winds. Such winds often blow along the bottoms of narrow, deep valleys. Desiccating dry season winds that blow steadily from the east can easily affect the unsheltered seedlings at the pricking out stage. In such places, there is also a danger of flooding. On the other hand seedlings can be protected from strong winds by adjacent mountain slopes and/or by natural vegetation or by the planting of shelterbelts and wind breaks. Since the most desiccating highland wind blows from the east, sheltered nursery sites are often found on the western sides of the mountains.

### 2.1.9 Availability of labour

A lot of labour is required for the construction of the nursery and later on periodically for tasks such as soil transportation and pot filling. Most nurseries in Ethiopia use very labour-intensive production methods with little reliance on chemicals or mechanical equipment. It is therefore essential that a nursery be sited only where sufficient labour can be recruited. There is significant seasonal variation in labour requirements at a nursery, and there may be a conflict with peak seasons for farm work.

## 2.2 Layout and design of nurseries

After a suitable site for a nursery establishment is selected, planning the layout of the nursery is the follow up tasks which assure the management and optimal use of the area.

There is no standard layout for the nursery since differences between sites (land availability, sloppiness, access to water etc.) must be taken into account. An ideal form for a nursery is from square (by which the expensive boundary fencing is kept at a minimum) to slightly rectangular shape (by which longer working lines are provided). Only seldom an ideal, level site can be found to meet these conditions: enough space for ideal nursery form, good road connections from any direction, water available in any corner. In practice the form of the nursery must be tailored into road access, into water points, and into sloppiness of the site. Some general considerations to have in mind when planning the overall nursery design and layout are discussed below.

### 2.2.1 Nursery production units

For management purposes, a large nursery must be divided in to suitable production units. The basic units are bed, compartment and block. Production should be arranged in such a way that one bed is sown at a certain time, one compartment is sown with a certain provenance and one block is sown with certain species. While laying out the land, care should be taken not to bury the top soil (which is important for seedling growth) and bring up the subsoil. This is especially important while raising bare rooted seedlings. The major production units in the nursery are nursery beds, compartments and blocks**.** Whenever designing blocks and beds, consider geometric shapes because it helps fast and easy management (follow up and seedling inventory) and avoids unnecessary space wastage.

**Nursery bed/ Seed beds**

The basic management unit in the nursery is the seedling bed. The bed is the smallest working unit and is selected to hold a convenient number of seedlings. It is a place where seeds are sown or in which the transplants of cuttings are raised. It is usually about 1.0 m wide because of the difficulty of reaching into the centre. When beds are narrower than 1m, paths between them take up too much space. Beds having 1m wide is acceptable with two practical advantages. First, the calculation of bed area and inventory of seedlings is simple. Second, the manual work over the bed-seed sowing, transplanting, weeding and watering are easy. For this reason, the bed width should not exceed 1.0 m.

The standard length of a nursery bed is 10m. It is a compromise between two factors. The longer the bed, the more optimal the use of nursery space will be. On the other hand, the longer the bed the more cumbersome the watering becomes.

One square meter of seedling bed can accommodate 156 pots of a diameter of 8cm. Thus, a bed of 1x10 m can accommodate a maximum of 1560 seedlings.

The working path between the seedling beds varies from a minimum of 0.50m to about 1.0. In flat or gently sloping areas, a bed width of 0.5m can be used, but if the soil must be terraced for the seedling beds, more space between the beds must be reserved, up to 1m or even more.

The seedling bed is prepared by first digging a shallow excavation. The depth of the bed is one-third the height of the pots. So, if the height of the pots is 15cm, the depth of the excavation is 5cm. A layer of coarse sand or gravel can be spread on the bottom of the bed to provide good drainage. In this case, the excavation should be dug slightly deeper. The earth that has been dug out of the bed may be left as a small ridge along the outer row of the pots to protect them from excessive heat.

All beds should be raised above the ground to prevent damage from flooding and sedimentation. If possible, the beds should run from north to south so that either side will receive equal exposure to sunlight.

The beds can be framed by wood, brick, stone, bamboo or plain wire. Wood is usually the best, but it is often too expensive. The frames should be constructed about 15 to 20cm high. Nursery bed could be: raised, sunken or level.

**Raised nursery beds:** are made in high rain fall areas. Raised beds are made 10 -15cm above ground level with support of bricks, stones or bamboo or bellies which prevent edges of the beds from crumbling during rains or while giving irrigation to the beds. These beds tend to prevent water logging. Even during heavy rains, the root zone is not flooded due to raised beds. Drainage in growing areas is also easy. Raised beds are good for those seeds which do not require more moisture for germination. Such beds are good for raising seedlings of teak.

**Sunken seed beds:** are made in dry areas. The objective of making sunken beds in dry areas is to avoid flow of water outside the bed. Sunken beds are made by excavating the soil in the bed area. These beds are usually 10cm to 30cm dipper than the normal ground level. It is better to connect such sunken beds to a common drainage line so that water does not stand during rains. Sunken beds are made for raising the seedlings in the bed or for keeping the polythene bags in the bed. Generally, if the seeds are to be sown in the bed, the depth is 10-15cm. However, if the polythene bags are to be kept in

the bed the depth is kept about 20 to 30cm depending upon the length of the polythene bags used. Generally, the depth of bed should be 5cm less than the length of the polythene bag. When polythene pots are used for raising the plants, it is advisable to put a polythene sheet equal to length, breadth and height of the bed. This prevents water to go down in the soil. It also prevents the roots of the plant from penetrating the ground.

**Level seed beds**: - are made in normal rainfall areas. These beds are easily irrigated by cans. The surface of the nursery bed should be perfectly flat or should have a slight camber. In order to enable good drainage in the beds, surface dressing is very important. If the soil is heavy, such dressings are more necessary.

**Compartments**

The second management unit in the nursery is the compartment. A suitable number of seedling beds are grouped into one compartment. Compartments are located at approximately 1m from surrounding unproductive land such as roads, hedges and windbreaks as well as from neighbouring compartments. A suitable number of seedling beds in one compartment are 20; the productive area is then 200$m^2$ and the maximum number of 8-cm pots is 31,200. However, the number of seedling beds in one compartment can vary according to the degree of the slope.

**Blocks**

The third management unit is the block. Several compartments (for instance, 4 to 6) are grouped together, framed by hedges and separated from each other with nursery roads or irrigation canals.Whenever designing blocks and beds, consider geometric shapes because it helps for fast and easy management (follow up and seedling inventory) and avoids unnecessary space wastage. Beds can be divided into two; beds for potted seedlings; and beds for bare rooted seedlings.

## 2.2.2 Infrastructure

The lists of infrastructure important for nursery development are as shown below:

**Buildings**

It is essential to have an office where records of seeds, sowing, etc., can be conveniently and accurately maintained and filed. If there is no office with a table and chair it will be difficult to record the basic information which is essential for future planning as well as documentation of past seedling production. The nursery office also serves as protection from wind and rain, temporary store and meeting and training place for nursery workers.

**Roads**

There are two types of roads in a nursery. A primary, all-weather road that is wide and suitable enough for trucks and tractors that shuttle to the nursery. This road also should traverse the entire nursery at least once to allow for efficient transport of seedlings. If the space and terrain allow, another all-weather road should be constructed as a perimeter and a third cross-road against the main traverse. The width requirement for the primary nursery roads is 5m.Secondary access roads, 3m wide, are needed to provide access to all blocks (and to separate them), buildings, the soil dump and germination compartments. These secondary roads do not need to be all-weather roads.

**Windbreaks**

Tender seedlings must be sheltered efficiently against the dry season winds. During the first years of nursery operation, temporary windbreaks around the compartments may be sufficient; however, the best windbreak in the long run is a living one. Hedges between blocks serve partly as windbreaks. The best windbreak is the one that does not stop the wind entirely, but slows speed by letting part of the air penetrate the obstacle. A solid windbreak (wall) creates air turbulence behind the wall, and the sheltering effect does not reach far.

**Fencing and shelterbelts**
A very effective tree for making live fence is *Cupressus lusitanica.* A good quality tree for effective live fence is that which can be pruned the side branch and the tip and 3 meters high and 2 metered wide at the bottom which by frequent pruning will be attractive and also effective against animals.

To form an effective live fence *Cupressus lusitanica* takes 3-4 years. To establish a live fence there should be a well prepared 2.5-3m wide land.

Steps for live fence establishment

1. Digging 1 meter wide place in the 2.5-3m area
2. Marking two lines 50cm apart i.e. from the 1m dug place 25cm from each side
3. In the marked line planting of strong and about 30cm high seedlings at an interval of 50 cm. The plated trees on one line should be in zigzag with the other line
4. Proper watering and weeding
5. When the seedling reaches a height of 1.5m pruning the tip and side branch so that it will be wider at the bottom and narrow at the top so that sunlight can easily reach the bottom parts.
6. In order to ensure that the branches are interwoven and maintain proper shape frequent pruning is necessary

The outer side of the live fence should be planted with shrubs (serving as barriers against livestock) while the inner one with trees. Tree/shrubs recommended for the outer and inner part are as follows: *Acacia holosericea, Eucalyptus Camsldunesis, Acacia. Senegal, Euc. Globulus, Ziziphus spina – Christi, Euc. Citriodora, Parkinsonia acculata, Casuarina cunninghamiana, Prosopis Juliflora, Casuarina equistifolia, Leucaena leucocephala Euphorbia tirucalli, Cupressus lusitanica, Grevillea robusta*

**Soil dump**
For a nursery with a capacity of 100,000 seedlings, a shed with 5 m x 3 m in area and 2 m height should be sufficient. The delivery truck should have road access to the storage dump so that double handling and moving by wheelbarrow are not required.

**Seed-extraction area**
Most nurseries collect and extract at least some of their own seed requirements. An area exposed to plenty of sunshine is needed for efficient seed extraction in some species.

**Compost area**
In dry climates it is usual to prepare compost in pits. A convenient size is 1-1.5 m deep, 1 m wide and 2 m long. The compost pit should have a roof to provide shed and protection from rain.

Source: Ed Verheij 2004

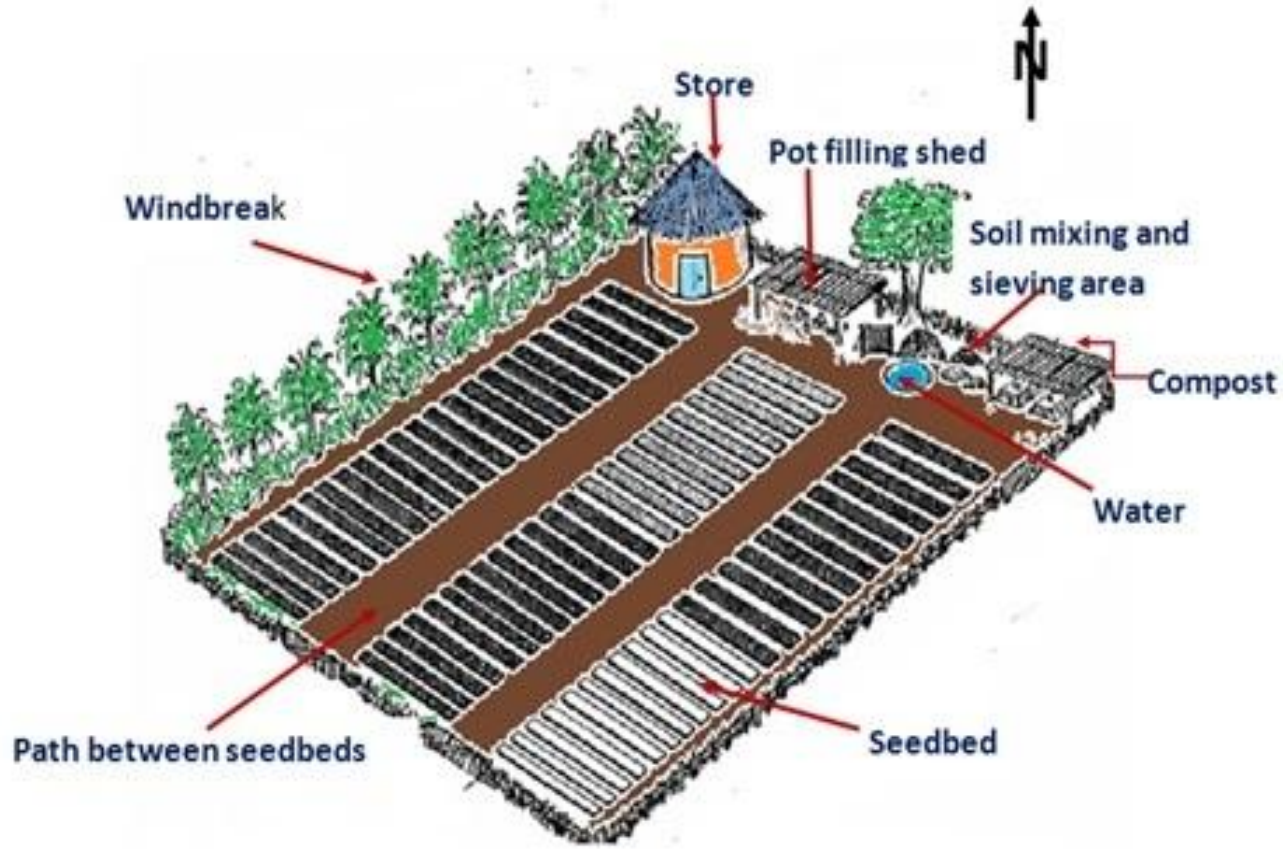


**Figure 2: Layout of nursery**

## Nursery equipment's and tools

Even if seedling production can begin with a minimum of infrastructure and tools, and the nursery appears to run well producing good seedlings for the first year of planting, a further plan for additional equipment and material must be prepared as soon as possible. The orders for materials must be placed well in advance, and the building of infrastructure (stores, shelters, office, housing, etc) should start at an early stage. By careful planning the nursery will run smoothly later when it is in full production.The minimum equipment needed for a labor intensive model nursery with the production capacity of 0.6 to 1.0 million seedlings per annum are listed on Table 5.

**Table 5 : Minimum equipment requirement for a labour intensive model nursery**

| No. | Type of hand tools and equipment | Unit | Quantity | Unit price | Total cost |
|---|---|---|---|---|---|
| A | **Hand tools and equipment** | | | | |
| **1** | Wheel barrow | No | 10 | 500 | 5,000 |
| **2** | Watering can | No | 15 | 100 | 1,500 |
| **4** | Spade | No | 10 | 90 | 900 |
| **5** | Rake | No | 10 | 100 | 1,000 |
| **6** | Crow bar | No | 1 | 120 | 120 |
| **7** | Hammer | No | 1 | 120 | 120 |
| **8** | Root pruning scissors | No | 5 | 100 | 500 |
| **9** | Hedge pruning scissors | No | 3 | 200 | 600 |
| **10** | Sickle | No | 4 | 30 | 120 |
| **11** | File | No | 1 | 10 | 10 |
| **12** | Knife | No | 2 | 25 | 50 |
| **13** | Bow saw | No | 1 | 250 | 250 |
| **14** | Seedling try | No | 15 | 100 | 1,500 |
| **15** | Pickaxe | No | 1 | 90 | 90 |
| **16** | Axe | No | 1 | 90 | 90 |
| **17** | Hoe | No | 4 | 85 | 340 |
| **18** | Sand sieve | M | 8 | 25 | 200 |
| **19** | Meter (50m) | No | 1 | 150 | 150 |
| **20** | Weighing Balance | No | 1 | 500 | 500 |
| | Subtotal | | | | 13,040 |
| B | **Polythene tube** | Kg | 1,000 | 60 | 60,000 |
| C | **Seed** | Kg | 10 | 250 | 2,500 |
| D | **Water supply** | | | | |
| | Water tanker | No | 1 | 5,000 | 5,000 |
| | Water pump | No | 1 | 10,000 | 10,000 |
| | *Subtotal* | | | | *15,000* |
| E | **Office and store** | | | | |
| | Store | No | 1 | 30,000 | 30,000 |
| | Fencing | Lsum | 1 | 7,000 | 12,000 |
| | Table | No | 1 | 500 | 500 |
| | Chair | No | 2 | 250 | 500 |
| | Shelf | No | 1 | 750 | 750 |
| | *Subtotal* | | | | *43,750* |
| F | **Labour** | PD | 15,000 | 20 | 300,000 |
| | Total | | | | 434,290 |
| | Contingency | | | | 43,429 |
| | Grand total | | | | 477,719 |

# MODULE 3: PLANNING OF PRODUCTION

## 3.1 Identification of demand

Planting material demand depends on the type (pot raised or bare rooted seedlings), species and quantity of plantlets to be planted on a specific area of land. Hence, what and how much we have to produce in our nursery depend on the suitability of species to the area and the density we want to achieve.

Major intervention areas calling for biological measures in watershed development are:

1. Land area to be afforested, re-afforested, or scattered Agroforestry system;
2. Gully and/or degraded land area intended to be rehabilitated with plantation;
3. Number of water harvesting structures to be associated with plantation;
4. Length of all SWC Physical structures intended to be supplemented with biological measures;
5. Number of seedling needed for replacement planting or beating up;
6. Also eventual demand of free market could be included

The following hypothetical example of a watershed illustrates on how to quantify demand of tree seedlings, grass splits and forage seed per year for production or procurement.

Let as assume for watershed X, the following intervention are supposed

I) Total communal land degraded in the watershed is 300 hectares. In this area, 60 km of Hillside terrace + trench is planned for implementation. Besides in 100 ha of the area, it is planned to plant Grevillea. There is also 50 hectares of forest area which demands enrichment planting.

II) Total Farmland in the watershed is 100 hectares. To address the land degradation issue on the farmland, 10 km of grass hedge, 50 km of soil bund and 20 km of stone faced soil bund is planned. Besides scattered trees are planned on the whole area.

III) There are 50 households in the watershed, for each household the plan is to develop a woodlot.

IV) The watershed has 2 km of active gully. 30 brush wood check dams and 20 sand bag check dams are planned for physical treatment. The total area requiring revegetation is 3 hectares.

Table 6 below shows the planting material demand of the hypothetical watershed presented above. As shown on the Table 6, the total demand of the watershed is 750,000 grass splits, 72.5 kg of forage seed, 661,669 tree seedlings and 320,000 grass cuttings.

**Table 6: Planting material demand of a hypothetical micro-watershed**

| No | Intervention areas | Unit | Total area or Km planned per year per micro watershed | Demand per km or hectare | | | | Total demand | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Grass splits (No) | Forage seed (Kg) | Tree seedlings (No) | Grass cutting per ha | Grass splits (No) | Forage seed (kg) | Tree seedlings (No) | Grass cuttings (No) |
| **1** | Communal land | | | | | | | | | | |
| **1.1** | Hillside terrace +Trench | Km | 60 | 5000 | 0.5 | | | 300,000 | 30 | | |
| **1.2** | Degraded communal land (Afforestation) | Ha | 100 | | | 5000 | | | | 500,000 | |
| **1.3** | Forest area (Enrichment planting) | Ha | 50 | | | 1000 | | | | 50,000 | |
| **2** | Farmland and Homestead | | | | | | | | | | |
| **2.1** | Grass hedge/strip establishment | Km | 10 | 10,000 | 0.5 | | | 100,000 | 5 | | |
| **2.2** | Terraces (Soil bund and stone faced soil bund) | Km | 70 | 5000 | 0.5 | 667 | | 350,000 | 35 | 46,669 | |
| **2.3** | Farmland (Agroforestry) | ha | 100 | | | 100 | | | | 5000 | |
| **2.4** | Homestead (Woodlot) | ha | 50 | | | 1000 | | | | 50,000 | |
| **3** | Gully | ha | 3 | | 0.5 | 2000 | 80,000 | | 2.5 | 10,000 | 320,000 |
| **Total** | | | | | | | | **750,000** | **72.5** | **661,669** | **320,000** |

- Forage seed refers to sesbania, pigeon pea or treelucern sown along Terraces in association with grass splits. According to the CBWDG, soil bunds are planted with grasses in association with leguminous shrubs. According to SLMP experience, direct sowing is the cheapest way of establishing leguminous shrubs along terraces.
- Grass splits refers to splits of Desho/Vetiver/Mulatto/Phalaris and etc. planted on terraces
- Grass cuttings refers to cuttings of elephant grass /bana grass /green gold, planted in reshaped gully walls and gully beds
- Tree seedlings refers to seedling of trees planted on open space between terraces/ degraded areas

## 3.2 Identification of appropriate species

There are two factors to be considered when choosing appropriate species for planting: 1) site characteristics and limitations which are also referred as agro-ecological suitability and 2) use or objective of the plantation (fuel wood, forage, land rehabilitation, stabilizing conservation structures, environmental protection and etc.).

Availability of tree/grass species and demand of communities is also considered. Annex Table 2 and 5 shows list of tree and grass species suitable for different agro-ecologies, land uses and purposes.

## 3.3 How to plan production of tree seedlings

Before we start to produce tree seedlings on nurseries, it is important to know the total demand of the area planned for rehabilitation. As explained on section 2.1, this is obtained from the annual plan of different intervention areas. Once this is obtained, the total quantity is fixed considering allowances and losses. After deciding the actual quantity planed and determining the species that fits the specific objective within the agro-ecology, the next important issue is to identify the type seedling we need to raise that should be categorized as containerized and non-containerized (bare-rooted) seedling.

It is very important as some species are better suited to growth in pots and others can be conveniently grown without container. However, many species can also be raised by either system. Considerate decision to choose species to the appropriate method leads to efficient planning. The decision to make choice of the type of seedling depends on:

- Susceptibility to hardship while lifting, transporting and planting;
- Susceptibility to soil-borne diseases while in nursery;
- Labour requirement versus realizing the objective;
- Successfulness after planting (survival rate);
- Space requirement in the nursery
- Growing time in the nursery;
- Cost efficiency

### 3.3.1 Determination of total quantity of seedling required

Annual need for tree seedlings can be calculated based on the planned area to be planted, and the planting spacing or density also referred as stocking rate.

The spacing (planting density) which determines the number of trees to be planted per hectare is again determined by the type of species, site characteristics and objective of plantation. The following is used as a guide:

- Slow growing species require closer spacing where as fast growing species need wider spacing.

- For fertile and favorable site, closer spacing is used and wider spacing for moisture deficit area.
- Closer spacing is used for products like pulp, fencing, fodder and fuel wood and wider spacing for products like timber.
- Very closer spacing is used for species planted with objective of soil and water conservation and fodder production in order to produce larger biomass and ensure maximum ground vegetation cover. In addition, if the main purpose is to produce biomass in a very shorter period of time and in large quantities, high planting densities is mandatory.

The most common spacing in plantation forestry is 2.5 x 2.5 m, or 1,600 trees per ha. In rotations of about 10 years, this density ensures an acceptable mean annual increment for eucalypts. Another common spacing, which is most frequent in Ethiopian fuel wood plantations, is 2 x 2 m, corresponding to 2, 500 trees per ha. This denser spacing enables somewhat shorter rotation, but it has also been found to be practical in eliminating some of the need for beating up.

However, in case of soil and water conservation there is a variation from that of plantation forestry on the purpose of planting. It requires different considerations like stabilizing structures, degraded land and gully rehabilitations which generally follow different principle for spacing. In this case, the required quantity of seedling production can be calculated on the bases of different purposes such as:

1. Land area to be afforested, re-afforested, or scattered Agroforestry system;
2. Gully and/or degraded land area intended to be rehabilitated with plantation (Total number is found by dividing the area to be planted with spacing of plantings) ;
3. For water harvesting structures associated with plantation; total number of seedlings is found by multiplying number of water harvesting structures with number of seedlings per structure;
4. For all SWC Physical structures intended to be supplemented with Biological measures; number of seedlings is found dividing the length with spacing.

### 3.3.2 Determination of nursery space requirement

Once, the total quantity of seedling required is determined and known, the area of the nursery can be calculated, based on the maximum number of seedlings to be produced. When making calculations of area required, a 20% allowance is made for losses.

The area needed for a nursery depends not only on the number of seedlings to be raised, but also on the proportion of seedlings that are raised as potted plants and bare-root seedlings. The diameter of the pot and the spacing between bare-root seedlings also has an effect on the area needed.

For example, if the pot diameter is 8 cm, then 156 pots per square meter can be accommodated in pot beds. If the pot diameter is increased to 10 cm, then only 100pots per square meter can be accommodated. The area required per pot increases proportional to the square of the radius of each pot. Therefore pot-bed area needed increases rapidly with increasing pot diameter. The number of filled tubes (n) per square meter can be calculated using the following formula:

$$n = (100/d)^2$$ (where d = diameter of pot in centimetres).

With this information the pot-bed area (A) needed can be easily calculated;
Total pot-bed area needed **(A)** is equal to the total seedlings needed **(N)** divided by the number of tubes (n) per $m^2$.

**Table 7: Pot-bed area needed for 10.000 seedlings**

| Pot diameter (cm) | Pots/$m^2$ | $m^2$ needed for 10.000 seedlings |
|---|---|---|
| **8** | 156 | 64 |
| **10** | 100 | 100 |
| **12** | 69 | 145 |

Bare-root seedling calculations can be based on the recommended spacing ranging from 5 by 5 cm to 20 by 20 cm.

**Table 8: Seedbed area needed for 10.000 seedlings**

| **Spacing** | **Seedlings/$m^2$** | **$m^2$ needed** |
|---|---|---|
| **5 by 5** | 400 | 25 |
| **5 by 10** | 200 | 50 |
| **10 by 10** | 100 | 100 |
| **10 by 20** | 50 | 200 |
| **20 by 20** | 25 | 400 |

Besides effective bed area, additional nursery space is needed for infrastructure that includes areas for paths between beds, roads, channels for irrigation, water tank, soil dump, stores, fences and windbreaks. If seed is collected by the project, an additional corner is needed for threshing and cleaning the seed.

The ratio of total area required for the nursery (including roads, windbreaks, etc.) to the area for pot beds is likely to be approximately 3:1. This ratio can be used for planning purposes.
For example; a nursery producing the following amount of seedlings;

| | |
|---|---|
| 200.000 potted seedlings in 8 cm pots | 1282 $m^2$ |
| 200.000 potted seedlings in 10 cm pots | 2000 $m^2$ |
| 100,000 potted seedlings in 12 cm pots | 1449 $m^2$ |
| 120,000 bare rooted seedlings at spacing 5 by 5 cm | 300 $m^2$ |
| Total production area needed | 5031 $m^2$ |

Based on the 3:1 ratio the total nursery area needed can be estimated as;
5031 $m^2$ production area + working area (5031/3) = 6708 $m^2$

## 3.4 How to plan production of grass splits and cuttings

Though planting leguminous shrubs is an excellent means of re-vegetation and stabilization of conservation structures, they are less effective than grass in stabilizing against erosion. Therefore, it is recommended that areas to be planted with leguminous shrubs be planted with grasses. Grasses are usually mixed with 10-50% leguminous shrubs. Leguminous shrub fixes nitrogen from the atmosphere and thus contributes to improving soil fertility. In addition to the above benefits, most of the shrub species provide higher protein when used as forage.

### 3.4.1 Determination of total quantity required

Tables6presented below shows a guide on how to calculate demand of grass splits and elephant grass/bana grass cuttings.

**Table 9: Guide for determination of demand of grass splits and grass cuttings**

| Intervention areas demanding planting of grass splits and elephant grass/bana grass cuttings | Planting space | Total amount required per kilometre or hectare |
|---|---|---|
| Grass hedge establishment along the contour | 10 cm | 10,000 per km |
| Soil bund, Fanya-juu, Bench terrace and etc. | 20 cm | 5,000 per km |
| Gully wall, Gully bed | 8 cuttings per $m^2$ | 80,000 per ha |

### 3.4.2 Determination of space requirement for multiplication

The following examples presented below will help to calculate the space requirement for vegetative multiplication of Vetiver, Desho grass and elephant/bana grass.

**For Vetiver and Desho grass in:**

**a) Central nursery/group nursery**

- If one starts with 285 clumps of vetiver or desho grass in a central/group nursery;
- 285 clumps (each clump contains on the average 20-50 splits) have nearly 10,000 splits;
- This is usually planted at a distance of 0.40 cm x 0.40 cm in a nursery.
- This requires an area of 2000 $m^{2.;}$
- After 3-6 months (depending on management). Each split planted can produce 20-50 new slips, corresponding to a total average of 350,000 splits.
- This will be enough to stabilize 70 km of soil bund or fanya-juu in a watershed.

**b) Individual nursery**

- 5 clumps of either of the grasses could be enough material for starting for one family.
- 175 splits (each clump containing about 35 splits) can be planted at a distance of 40 cm x 40 cm from each other in a nursery of about 28 $m^2$
- 4-8 months later, each splits planted can produce in turn 35 new splits, corresponding to a total of 6125 new splits.
- Transplanted every 20 cm on anti-erosive soil bunds, these 6125 splits can vegetate 1.2 km of soil bund.

**For Elephant grass:**

- Elephant grass is propagated by stem cuttings or splits.
- Splits generally take more labour to prepare (uproot) and to plant but result in quicker establishment.
- Using cuttings is more economical than root splits.
- Elephant grass is mainly used for gully re-vegetation, re-vegetation of degraded lands and bund stabilization (dwarf elephant grass).
- If our intention is to re-vegetate a gully of 1 km length (0.7-1 ha). This requires 56,000-80,000 cuttings (18,666 -26,666 canes).
- To multiply this in a nursery, a minimum of 500 $m^2$ nursery area is required.

## 3.5 How to plan demand of seed required for nursery & direct sowing

The amount of seed we need to purchase depends on the purity of seeds and germination percent. For example, if we want to produce 60,000 seedlings of a given species, the amount of seed we want to avail is calculated as follows:

### 3.5.1 Purity percent

In order to calculate the purity percent of a certain seed lot, a sample of 10 gram is taken and counted. Assume that the number of pure undamaged seeds in 10 grams of seed is 284. This implies that there are 28,400seeds per kilogram. Then to arrive at the purity percent weight the pure seeds. Assume that it weighed 8.6gm. The purity % = (8.6/10) =86%.

### 3.5.2 Germination percent

Information on germination rates for each seed lot is essential to determine appropriate sowing rates and calculate the total amount of seed required for the planned production levels.

In order to determine the germination percent, count 200 seeds from the pure seeds (record provenance, sowing date). Then count the number of seeds germinated (every week). Remove counted ones. When conducting germination test is not possible, Annex table 1 can be used as a reference.

For example if 32 seeds are germinated after one week, 104 seeds after two weeks and 122 seeds after three weeks, the germination percent is calculated as:

$$Germination\% = \frac{122}{200} * 100 = 61\%$$

Once we know the purity and the germination percent, it is possible to know how much seed we need to produce the required seedlings. If for instance, our target is 60,000 seedlings,

The seed demand is calculated as follows:

Given germination percent is 61%,

$$Number\ of\ seeds\ required\ is\ = \frac{60{,}000}{0.61} = 98361\ seeds$$

And the weight of these seeds is:

Assuming the number of undamaged seed per kilogram is 28,400 (see 3.5.1),

$$Amount\ of\ seeds\ = \frac{98{,}361\ seeds}{28{,}400\ seeds\ per\ Kg} = 3.463\ kg$$

Since the purity is 86%, the total amount of seed we need is:

$$Total\ amount\ of\ seeds\ required\ = \frac{3.463\ kg}{0.86} = 4.027\text{Kg}$$

Since all germinated seeds does not reach planting site, consider 20% loss which gives us a total of 4.83244 kg. This is the amount of seed we have to order for purchase or collection.

### 3.6 Estimating proportion of direct sowing

Forage seed like sesbania, pigeon pea or treelucern are sown along Terraces and gully beds and walls in association with grass splits and cuttings and alone on degraded Hill sides and grazing areas. According to SLM experience, direct sowing is the cheapest way of establishing leguminous shrubs on those land uses.

The proportion of direct sowing in watershed development could vary between 20-30 % depending on the proportion of terraces constructed on farmlands and gullies planned for rehabilitation.

# MODULE 4: NURSERY SOIL PREPARATION

## 4.1 Obtaining potting mixes

The growing media or "soils" that are used in pots (or tubes) are possibly the most important factor in growing high-quality, healthy seedlings. Careful selection, mixing, treatment and handling of the components of the potting soil should provide the best possible growing conditions for plants, resulting in healthy seedlings that have a high chance of survival in the field.

The potting mix must provide water, nutrients, oxygen and physical support for the seedlings as long as they are in the nursery. A single source of soil is not usually able to provide all these requirements, so it is necessary to mix several components together to produce the potting mix. We must rely on mixing soil, sand and manure/compost in such proportions that the basic requirements for healthy plant growth are fulfilled.

## 4.2 Soil components

The basic soil component for pots is sandy loam or loamy sand. It should be found in sufficient quantities either in the nursery or in the vicinity of the nursery. Availability of soil is one of the criteria for choosing the nursery site. The soil particles in sandy loams and loamy sands are ideal to provide good soil aeration, root penetration and easy watering.Often the ideal mineral soil is not found. The available topsoil inside the nursery or in the vicinity, is either too heavy (clay) or too light (sandy). Neither of these options is good, but both of them are usable if their basic properties are understood.

Clay soils have a tendency to become hard and compact. They absorb water too slowly and the irrigation of pots becomes difficult. However, clay soils can be improved by adding sand or some humus rich soil. The presence of clay soil helps the soil bound the roots & form soil cylinder (improves adhesion). Nursery residues are added to mixture, they must be chopped into small pieces. As such they decompose quicker, and this later facilitates mixing the compost into other nursery soil.

## 4.3 Organic matter

It is widely accepted that organic matter has several important benefits for producing a high quality potting mixture, and thus helping to produce high-quality seedlings. The main benefits of organic matter are the following:

- It binds together the mineral particles of soils into aggregates. This improves soil structure and therefore the supply of oxygen and water to the plants.
- It is a source of nutrients for plants. These nutrients are released slowly as the organic matter gradually decomposes,
- It regulates the supply of nutrients by holding them in readily available forms and reducing losses into drainage water through leaching.
- It helps to control root diseases through a general reduction in the level of pathogens by antagonistic micro-organisms that decompose the organic matter.
- It may stimulate seed germination, root development and general plant growth through the plant-hormone-like activity of some of its components.

## 4.4 Soil mixtures

A common problem is that soils are too "heavy" in texture; that is, they contain too much clay and silt. These results in poor aeration and little pore space, both of which reduce root growth. The final mixture should have a texture classified as "sandy loam" or "loamy sand".

The proportions of soil, sand and compost/manure to be used will depend on the individual nursery because the texture of the soil component used in each one varies. There can be substantial changes even at one nursery if the origin of the mix components changes from year to year.

A mix containing soil, sand and compost in the ratio of 2:1:1 is recommended as adequate for the healthy growth of the majority of species. Some nurseries had adopted ratios such as 3:1:1 and found

seedling quality improved due to the improved root growth in these lighter-textured mixes. If the high cost precludes using sand in such a high proportion, then try to include as much compost as possible, up to a maximum of 40%.

If possible, forest topsoil, which often already contains a high proportion of sand, should be used to produce the final potting mix. Such topsoil often also contains useful organic matter and has a lower pH than dam silt, but it may also contain a lot of weed seeds.Now, the different nursery soil components are ready: local nursery soil as a basic soil, forest soil, some compost, some cattle manure. All the components have also been sieved to a uniform size that is easy to mix, pour and press into seedling pots. How should the different components be mixed?

The determining factor in mixing is the structure of the basic mineral soil. If a good sandy loam or loamy sand has been found, only some compost, cattle manure or forest soil is needed to improve the basic material. The mixing proportion of basic soil to humus soil is 80-20. If the basic soil is clay, some sand must be added to make the mixture lighter. The mixing proportion of clay to sand to humus is 50-40-10. In some areas only sandy topsoil is available for use as the basic material. In such cases it is better to transport humus-rich soils-if available- than poorer clay materials. Preferable mixing proportion of sand to humus soil is 67-33 (3 to 2). Suitable mixing proportions are found by test and experience. All soil particles must be sieved and thoroughly mixed before pot filling.

## 4.5 Determining soil volume

Potting soil is bulky material. Its availability must be secured well in advance by looking for a soil source that is sufficient and by having enough transport capacity to carry the soil to the nursery. The transport of nursery soil is the first activity in preparations for the coming nursery and planting season. It should begin immediately upon completion of the main rains when the roads to the soil source are passable.

For potted seedlings the amount of soil required is:

$V = \pi r^2 XLxN$

Where $\pi$ = 3.14
V= Volume (amount) of soil required
r = radius of container
L = length of container
N = no of seedling to be produced

**Example.** If we are planning to produce 500,000 seedlings in pot of size (5cm diameter and 15 cm height), how much soil do we need?
For potted seedlings the amount of soil required is

= 500,000*0.025$m^2$*3. 14 *0.15m
= **147.278m3**

To produce seedlings on bare root (seed beds) 1$m^3$ of is enough for 10$m^2$ of bed size (10*1m).

## 4.6 Preparation of polythene pots

### 4.6.1 Size of container (Pot)

The size of seedling that can be grown depends primarily on the size of container available. A general guide is that seedling height should be not more than twice the length of the tube. This is dictated by the fact that, for good survival, seedlings must have a good root/shoot ratio. If large seedlings are grown in small tubes they will invariably have a low root/shoot ratio and subsequently poor survival.

To decide on container size it is therefore essential to have information on the size of seedlings that constitutes the most suitable target seedling for planting. From experience in other countries it is recommended to have a seedling at least 20 cm tall for planting in relatively dry climates. Experience suggests that tubes at least 15 cm long would be required. A 15-cm long tube is suitable for growing seedlings with a height of 15- 30 cm. If larger seedlings are to be grown, then longer tubes are

required. If grass competition is likely, then larger pots, in which larger seedlings can be grown, should be used. This is particularly relevant to eucalypts which are not tolerant of grass competition during the first few years after planting.

It is a general rule that the dryer the climate, the larger the container required. The reliability of rainfall in the post-planting seedling establishment period of about a month is also very important in determining container size. The less reliable the rainfall, the larger the container required. From experiences in Ethiopia, containers with 8-12 cm in diameter and 15-20 cm length for areas with rainfall of 400-800 mm per year are suitable.

It is clear that larger tubes result in better survival because they allow for development of larger root systems and greater moisture storage, but of course larger tubes are more costly. Larger tubes incur greater cost for tubing, potting mix, watering, weeding, transporting to the planting site, etc. A balance must be achieved between greater production and planting costs and increased survival when using larger pots. It is suggested that the other, cheaper, nursery-management improvements suggested in this manual be implemented first. Remember that if the tube diameter is doubled while maintaining a constant length, the volume and weight of the tube increases four-fold.

A suitable pot size also depends on the species grown. Larger pots, and also larger seedlings, are needed for beating-up (replanting to replace dead seedlings in plantations) to enable them to catch up to the seedlings that were planted earlier.

A 5-cm diameter tube can be from 10 to 20 cm long. A practicable length is 15 cm, as is commonly used in highland nurseries. Problems with air pockets can easily develop with longer tubes unless filling with the potting mix is done very carefully, providing just sufficient compacting to prevent air pockets. There are also difficulties with stability of long pots when standing them in pot beds, and this can result in non-vertical tubes with uneven root development within the pot. For 8-cm diameter tubes a length of 20-25 cm is appropriate. In general terms, the ratio of tube length to diameter should be about 3:1.

Tubing for containers must be ordered in adequate time so that it is in stock at the nursery in required quantities before pot filling begins. Using tubing of 0.05-mm gauge, 1 kg of plastic (polyethylene) will produce about 1,000 tubes of 8-cm lay-flat diameter and 15 cm length. One reel of tubing should produce 4,500 pots, so that one carton which contains two reels should produce 9,000 pots. For 1 million seedlings, 1,000 kg of plastic rolls would be required. For pots of 8-cm diameter and 20-cm length, about 500 pots can be obtained from each kilo of plastic. Therefore, for these larger pots that are usually used in lowland nurseries, you will need 2,000 kg of plastic roll for 1 million seedlings. When ordering plastic it is usual to specify the width of the tubing when it is laid flat. Thus if you order 8-cm diameter lay-flat tubing it will produce filled pots with a diameter of 5 cm.

Currently the tubing is cut to the required length of individual pots by laboriously cutting single lengths by placing the endless tubing on a wooden board marked at regular intervals. In this way 20 pieces can be cut at a time thus greatly improving productivity. The diameter of the round-wood determines the length of the pots obtained. If the diameter is 4.8 cm, tube length will be 15 cm, while a diameter of 6.4 cm will provide 20-cm long tubes. The round wood is best turned in a lathe, but it is also possible to use a debarked piece of branch of the required diameter. The efficiency and convenience of the pot-cutting roll can be further improved by fitting a winding handle to the round-wood.

Pot size can be selected from diameters between 4 and 10cm. Also the length can vary. The smallest pots are usually 10 cm long; the widest pots can be up to 25cm long. The general rule holds: the bigger the pot and the earth ball, the better the success in planting. However, the pot soil that can be obtained and transported becomes unbearable if the pot size is increased. If the diameter is doubled and the length of the pot remains the same, the volume of soil needed becomes four fold (Table

below). Therefore, the pot size must always be a compromise between secured planting and practical limits in soil transport.

The pot size also depends on the tree species. Broad-leafed trees or fruit trees require larger pots than eucalyptus.

**Table 10: Pot size and the soil needed for one pot**

| Diameter (cm) | Length (cm) | Volume ($cm^{3)}$ |
|---|---|---|
| **6** | 15 | 424 |
| **6** | 20 | 565 |
| **7** | 15 | 577 |
| **7** | 20 | 770 |
| **8** | 15 | 754 |
| **8** | 20 | 1005 |
| **9** | 20 | 1272 |
| **9** | 25 | 1590 |
| **10** | 25 | 1963 |
| **12** | 25 | 2826 |

### 4.6.2 The need for plastic tubes

Plastic tubing is usually the most important piece of imported material in the nursery. Plastic tubes are needed early in the nursery production preparations: at the start of pot filling. The amount to be procured should be calculated carefully. For example a polythene tube with 8cm laid flat diameter we can get an average of 500 pots (15cm height). Therefore a nursery planning to produce 500,000 seedlings using 8cm laid flat diameter needs about 10 quintals of polythene tube.

## 4.7 Potting methods

The plastic pots are filled with soil mixture either by hand or by using a funnel. The pots are filled first from the bottom to a height of about 5cm. This bottom soil is compacted. The remainder of the pot is filled loosely. Packing pots in stages is important to avoid air pockets inside the soil. After filling, the pots are transferred to beds where they are packed tightly in an upright position to await seed sowing or seedling transplanting.

### 4.7.1 Seedbeds

The soil used for seedbeds in nurseries is often the locally occurring topsoil. It is better; however, if a separate mix can be used for seedbeds to cater for the special demands of germinating seeds. Seedbed mix should be sieved through a 2-mm mesh sieve to ensure larger particles do not interfere with germination. It is even more important than for potting mixes that seedbed mixes should be well drained, as disease is especially prevalent in germinating seeds.

Light-textured mixes also allow the roots to be removed more easily without damage at pricking-out (transplanting) time. The proportions of soil and sand to use for a good seedbed mix depend on the specific particle-size distribution at a given nursery. A mix of one part river sand and one part sandy loam soil should usually be suitable. There is no need to add compost to seedbeds as the seedlings will not grow there for such a sufficiently long time as to require large amounts of nutrients. Indeed, compost often increases the severity of disease in non-pasteurized mixes.

### 4.3.2 Sieving and mixing

The potting-mix components should all be sieved before mixing together so that no large clods, stones, roots, etc., are present in the final mix. A mesh size of about 1-cm is usually adequate, but 5-

mm mesh is preferred and often recommended. The sieves in most nurseries are made with the same wire mesh used to make beds, and they have proven quite satisfactory. For seedbed soil, a 2-mm mesh sieve is better. For covering seed and for refilling holes during pricking-out, it is best to use fine 20 sand which is below 1 mm in diameter. If such fine sand is not available, then at least the sand should be sieved through a 2-mm mesh.

After sieving, the dry components are thoroughly mixed to provide a uniform distribution of soil, sand and compost. The different components should be measured by volume, for which a wheelbarrow is convenient as a unit of measurement. To facilitate easier mixing, it is good to dump single barrow loads of the various mix components in alternating sequence into a heap. This heap is then turned over to make another adjacent heap. This process of repeated turning is continued three or four times, backwards and forwards, to obtain a uniform mixture.

### 4.7.3 Filling pots

After the preparation of a suitable potting mix, and having cut polythene tubes to the required length, you can begin pot filling. The soil mix should be moist but not saturated to facilitate rapid filling of pots to the required density.

If open-ended tubes must be used, it is only necessary to compact 3-5 cm of soil in the bottom of the tube. This can be conveniently done with a flat-ended round stick of about 4-cm diameter. Alternatively, a tube is compacted by hand pressure at the top end only after filling and the tube is then inverted when it is placed in the pot beds.
The rest of the tube should be filled with quality soil mix to the top of the polyethylene, with only slight compacting so that air pockets do not develop in the tube. The development of air pockets is especially likely with longer tubes and this is the main reason why tubes with a diameter of 5 cm should be no longer than 20 cm.

The filled tubes can conveniently be stacked and carried to pot beds in robust planting trays. The tubes must remain in a vertical position all the time, in contrast to the compacted soil tubes which are stacked horizontally for convenience of nursery workers. Pots should be placed into pot beds exactly vertically to prevent roots growing unevenly within the pot. Pots should be packed tightly, but without deformation. This will leave spaces for drainage of any excess water between pots.

# MODULE 5: SEED PREPARATION

## 5.1 Seed supply, processing and storage

### 5.1.1 Seed

Successful raising and growing of trees depends on the right kind of seed, good quality, sufficient amount and availability at the right time. Seed can be obtained from distributors or collected locally.

### 5.1.2 Seed supply

In any stand of trees of the same species, whether in natural forest or plantation, the individual trees often appear different in many respects, for example, vigour, health, stem form, branch size, fruit, fodder or resin production.

When we wish to produce more trees of the same species, we aim to use plants that have the best characteristics in respect of the product we want. To achieve this, we must collect seeds from trees which show one or more of the desired characteristics.

Selecting good trees as a source of the seed (mother trees), however, will not in itself ensure that we reach the goal of growing more trees with the desired characteristics. The ways in which the seed are collected and subsequently processed, transported, stored and pre-treated also have critical consequences for seed quality and, eventually, the final results of the tree plantings.

Seed orchards can easily be established around nurseries and Farmer Training centres. These sites serve both the demonstration, teaching and as sources of seeds of desired species. The huge gap between demand and supply of seeds can be easily minimized locally if such approach is followed.

Moreover, strategies like organizing landless people in seed collection, processing and marketing will enhance supply of local species. There are in many Woredas forest areas owned by either the state or the community. These sources can be effectively utilized if such organized groups are engaged is the seed production Endeavour. It serves two purposes: the first is creating livelihood opportunities and the second one is reducing the grave shortage of forest tree seeds

**Observable characteristics of a good seed source (site and mother tree)**

The first step in good seed procurement practice is to obtain your seeds from well-identified locations and to make good records of the sources. The next step is to examine the quality of the seed source. There are a number of basic conditions that must be fulfilled if an area is to be considered as a seed source:

- The conditions of the locality of the seed source must match as closely as possible the conditions of the locality where it is planned to plant the trees you will grow from the seeds;
- The trees must be sufficiently old and big so that the health, vigour, flowering and quality of the product we are looking for can be satisfactorily evaluated;
- The trees must be healthy and vigorous. The appearance of the trees in respect of the end use (i.e. timber, fuel, fodder, fruit, etc.) must not be inferior to trees of the same species found in other areas in the neighborhood (see Fig 3 below);

**Figure 3: Selection of superior phenotypic seed tree**

- In years of good climatic conditions most of the trees in the area must flower and set fruit;
- If they do not, the genetic and physical quality of the seeds obtained is not likely to be satisfactory. In the case of plantations, there must be confirmatory records of the health and vigour of the trees. If there is no information about the origin of the trees in the plantation from which you plan to collect seed, then only use the source temporarily until a better one can be located;
- In the case of naturally occurring stands, the location must provide at least 30 healthy and vigorous trees, or groups of trees, spaced at approximately 100m. Trees growing close together are assumed to be related, therefore, it is better to collect seeds from trees that are far apart which represent wider genetic variation;
- In plantations there must also be a minimum of 30 healthy and vigorous trees. However, there is no requirement for a minimum spacing other than the spacing required for good crown development, good flower and fruit production. In plantations, neighboring trees are assumed not to be closely related provided the seed from where the trees originated were collected properly;
- If collecting seeds from 30 trees, or groups of trees, does not provide a sufficient amount of seed, and then do the following:
    - In plantations, simply increase the area you collect from until the demand for seed is met. As an alternative, other areas may be located. In natural stands, collect from trees in between the 30 initially selected trees but make sure you collect from specimens in all directions around the initial 30 trees.
- The source must be reasonably easy to reach with a vehicle. Only if there is no other choice should an inaccessible location be chosen as a seed source; and
- It should be possible to protect the seed source from destruction or damage such as by browsing, cutting and lopping by humans, or fire.

**Seed collection techniques**

There are various methods for collection of tree seed. In each case the choice of method depends on many factors, for example type of fruit, kind of tree, stand and site characteristics, amounts to be collected, available equipment, safety, weather and, of course, the skills of the staff available. Details of techniques and methods will not be discussed here. But only some important points to remember when planning and carrying out seed collections are mentioned below.

Four rules are important when locating seed trees and when collecting seed:

i) Any tree you collect from must be healthy and show vigorous growth;
ii) Avoid collecting the earliest maturing fruits or seeds or those that have fallen to the ground. Such seeds are often damaged by insects or are empty. If there is no alternative, then check a representative sample of seeds to see if they are viable;
iii) In the case of fruits that have a soft moist pulp (pericarp), do not collect those that have become brown or black, or where the pulp has dried out or become fermented; and
iv) Avoid collecting fruits or seeds that have come into contact with the soil as this will often result in the seed being contaminated with various fungi (see Fig. 2 below)

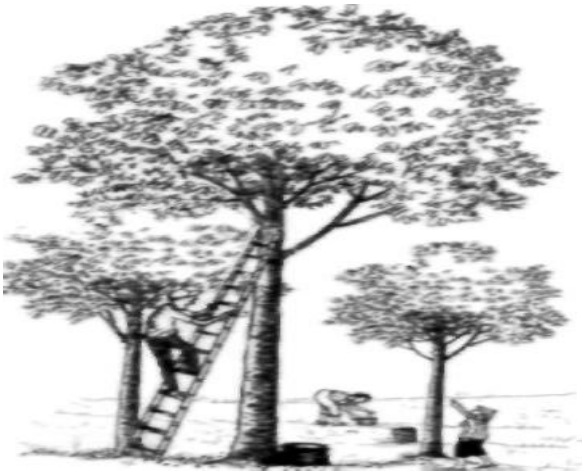

**Figure 4: seed collection in the crown (climbing)**

**Seed processing**

The collected seeds need to be dried to the required moisture content prior to storage. Do not store wet or fleshy seeds and fruits since they easily rot and get spoiled. Therefore, the collected seeds must be spread over canvas or mats for drying in the sun and air. During the drying process, turning over of the seeds until they are fairly dried is necessary. To separate some seeds from their fruits, threshing and winnowing may be required. After the seeds are well sorted, they should be packed in sacks or bags and stored in a dry place.

Seed processing may require also extraction from the fruits or pods and drying them before sawing. If seeds are enclosed in a fleshy fruit, remove the flesh with knife, wash off the rest under water and sow the seeds immediately. For seeds in a seed pod, such as *Luceana leucocephala*, let the pods split open naturally by laying them in a semi-shade place. Similarly for other fruits with hard coat, drying them in semi-shade or gentle cracking could be applied.

**Storage of seed**

The seed storage needs to be free from moisture, a well-ventilated and raised bed and free from pests. In order to keep the seed cool, storage along a wall facing a south westerly direction should be avoided since this wall tends to be warmer than the other walls during the afternoon. Also seed should not be stored too high in the building because hot air will concentrate under the roof. The sack, jars, or boxes with the seed must be placed in such way that air can circulate around each container. For this purpose shelves can be placed in the store. Some seeds can be dried to low moisture content of about 5% and be stored successfully at low temperatures. Others cannot survive drying below 20-50% moisture content. Therefore, seed storage requires the knowledge of the nature of the species. Several species of leguminous and other plants have high longevity (surviving for long years), For example, seeds of Acacia, Albizia, Cassia, Leucaena, Prosopis, Hibscus etc, can be successfully stored for more than 20 years.

## 5.2 Preparing seed for sowing

### 5.2.1 Seed pre-sowing treatment

After collection, seeds from many forest trees are completely or partially dormant; they are not ready for immediate germination. These seeds need pre-treatment before sowing. Dormancy has evolved in trees to help their survival and spreading into new areas. A good example is *Balanites aegyptica*, a scattered pioneer species occurring in semi-arid and arid low lands throughout the Sudano-Sahelian belt. If the seeds drop under the mother tree, they will hardly germinate. The fruit of Banalities must first be eaten by animals such as goats before the seeds inside the fruits are ready to germinate. Seeds that have passed through the intestinal tract of ruminants (especially goats) particularly germinate well.

There are 5 different categories of seed dormancy (Maydell 1986):

- Seed coat dormancy,
- Embryo dormancy,
- Immature embryo,
- Induced or secondary dormancy, and
- Double dormancy, combining two or more of the above strategies.

Seed coat dormancy is the most common in dry land species, and it occurs in many legumes (like acacias). The hard seed coat prevents the uptake of moisture, and it must be softened or broken down by pre-treatment.

Dormancy caused by hard seed coat can be overcome by several methods. In a large nursery the most practical way is to immerse seeds in boiling water that is 4 to 6 times the volume of the seed lot. The water and seeds are then allowed to cool for 24 hours. After this, they are ready for sowing. This is the usual practice with *Acacia decurrence*. There are various treatments which can be applied to seed to reduce seed dormancy so that germination becomes more rapid and uniform. This naturally helps to simplify nursery management, and also makes it more efficient and, therefore, cheaper to raise seedlings. The types of seed pre-treatment can include the following.

**Scarification**

The objective of the scarification method is to reduce the thickness of the seed coat so that it becomes more permeable to water. This can be achieved by nicking, filing, rubbing with sandpaper or rough stones. This method is time consuming and so is usually only used with larger seeds and when the seed source is scarce or valuable. If a cement mixer is available it is possible to scarify large quantities of seed by tumbling the seed with gravel or sand. The nick in the seed coat should be made opposite the point where the seed was attached to the pod; this point is often a tiny light-coloured spot at one end of the seed. The nick should be no more than 1mm square to ensure that the embryo is not damaged. Soaking the seed in cold water for 24 hours before sowing, but after scarification, should further hasten germination.

An extreme type of scarification is practiced by removal of the whole seed shell; this is usual with the seed of *Olea europaea* subsp. a*fricana,* and should also be tried with *Zizyphus* species. Cracking of the seed shell must be done with great care so that the seed itself is not damaged in the process.

**Soaking in water**

**Hot water:** Seed-coat dormancy of many leguminous species can be successfully overcome by treating with hot water. This is a quick and easy method and allows the treatment of a large number of seeds economically. A typical treatment might be carried out as follows:

- Boil some water—about 10 times the volume of the seed to be treated;
- Remove water from heat and immediately place the seed in the water; and
- Allow the water to cool gradually with the seeds in it.

The seed should be sown immediately and not dried or stored. Sometimes, soaking for further 24 hours will improve germination rates and speed. The precise temperature of the hot water into which seeds should be immersed varies with species, as does the most suitable period for soaking. Do not allow the water to heat to boiling point as this is injurious to most species.

**Cold water:** Many seeds germinate readily after soaking for 24 hours in water at ambient temperature. Prolonged soaking may benefit some species, but unless the water is changed daily there is risk of injurious effect on the seed. The use of running water to leach out inhibitors from the seed is also an effective pre-treatment for some species. A useful way to separate viable seed from non-viable seed and chaff is to float the seed in cold water. Viable seed are heavy and tend to sink, while non-viable seed are light and tend to float.

**Chemical treatments**
A wide range of chemicals have been used for seed pre-treatment, including acids, hydrogen peroxide, potassium nitrate, silver nitrate, potassium permanganate and a variety of trace elements. The most widely used of the chemical methods is the use of concentrated commercial sulphuric acid. The seed is soaked in the acid for a period long enough to weaken and soften the seed coat but without damaging the seed. A period of 10 minutes may be sufficient, but up to 1 hour may be necessary for maximum germination in some species. After removal from the acid, the seed must be thoroughly washed to ensure that all the acid is rinsed off the seeds.

The species which respond well to acid treatment are usually those which also respond well to scarification or treatment with boiling water (e.g. hard-coated leguminous seed), and it is often reported that equally good results can be achieved by any of these methods. Which method you chose, therefore, may depend mainly on which method is most convenient. The danger posed by the use of concentrated acid by unskilled workers is, however, a serious disadvantage. The dangers of acid to safety of workers and equipment's suggest it should not be used for routine pre-treatment of seeds.

**5.2.2 Time of sowing**
If seed can be stored for some time without undue loss of viability, then you can be flexible in deciding convenient sowing dates. If, on the other hand, seed rapidly loses viability in storage (e.g. *Azadirachta indica)* it should be sown as soon as possible after collection. If seed can be stored, then the sowing date is primarily determined by the anticipated date of planting and the size of the target seedling that is desired at that time. In the Ethiopian highlands the seedlings should be ready for planting any time after the beginning of July, by which time the rainy season is usually established and labour for planting has been organized.

The target seedling at planting time should be about 30 cm tall if 15-cm long tubes are used and about 40 cm tall with 20-cm long tubes. The sowing date can then be decided if we know how long it takes to produce a seedling of such height. The time to grow the required seedling is subtracted from the planting date and this provides the sowing date. In order to decide what will be the correct sowing date you should allow sufficient time for the following: pre-treatment of seed before sowing, sowing, germination, pricking-out, growing seedlings to the required size, hardening-off, and grading.

The time required for several of the above operations is very much dependent on the species grown. This applies especially to the time required for germination and the time required to growing a given species to the required size. Time required for hardening-off should be about a month, but this is an operation which is frequently not allowed for in the calculations used to decide sowing dates. The environmental conditions at a particular nursery also affect the growth rates of seedlings, the most important being temperature, which is highly correlated with elevation. Other environmental factors of some importance are wind, relative air humidity and frosts or minimum temperatures. Frost in particular may dictate that sowing time. Frost sensitive species are delayed until at least February, by which time the probability of frost is reduced. The best guide to sowing dates should be based on the experience obtained at each individual nursery from the results of previous years. The use of a production calendar showing the dates of sowing, pricking-out, etc., is most useful to record current operations and help to plan operations for the following year.

If a large amount of seed needs to be sown, it should not all be sown at the same time because there will be a peak in germination and many seedlings attaining the same size. Unless there is abundant suitable casual labour, it will be difficult to prick-out all the seedlings at the correct time. It is, therefore, advisable to sow large seed lots over a period of several weeks. This will also help to produce more uniform plants at planting time because the seedlings produced from the earlier sowings can be planted before those from later sowings.

If the sowing date is too early, large plants with a poor root/shoot ratio will be produced. This situation can be partly salvaged by shoot pruning of excessively long seedlings. Most broad-leaved species, including *Acacia* and *Eucalyptus*, can be shoot pruned once or even twice and this restores a

more favourable root/shoot ratio, which is helpful for obtaining good survival after planting. If sowing is done too early, it will be necessary to root-prune repeatedly and this adds to the cost of raising seedlings. Hardening-off should be started earlier than initially anticipated if it appears that otherwise the seedlings will be too large at planting time. This should result in control of further height growth while allowing some increase in diameter of the seedling stems, and so good quality seedlings can still be produced.

If sowing is done too late, the seedlings will be too small at optimum planting time and it is likely that there will be no time for hardening-off. This combination of small, unhardenedseedlings is likely to result in poor survival after planting. From the above considerations it is evident that sowing too late is likely to present worse problems than sowing slightly too early. Early sowing should help to produce well-hardened seedlings, but nursery costs will be higher because of higher labor costs incurred over a longer growing period. If there is insufficient labor to effectively root-prune, great care should be taken with determination of sowing dates so that overgrown plants with poor root systems are not produced as a result of sowing too early.

### 5.2.3 Sowing methods

When deciding on raising tree seedlings there are two basic options available. One consists of sowing seed directly into the ***container*** in which the seedling will remain in the nursery. The alternative is to sow seed at a relatively high density into ***seedbeds*** or seed trays where they germinate and are allowed to grow for only a short time before being pricked-out (transplanted) individually into new tubes. Some species are better suited to grow in pots and others can be conveniently grown as bare-root seedlings, while many species can be raised by either system.

Although direct sowing is usually more convenient, sometimes it is necessary to use seedbeds or seed trays and to prick-out the seedlings. A major advantage is that germination of seed can be concentrated in a small area, rather than spread through the whole nursery. This allows specialized techniques to be used under close supervision. In particular, improvements can be made to the sowing medium and to watering, shade and protection from insects, diseases and rodents. Seedbeds or seed trays are also recommended when:

- Viability is expected to be low (less than 40%);
- Germination is prolonged and erratic;
- Seed is very small, e.g. *Eucalyptus;*
- The seed is scarce or expensive; and
- Several plants germinate from one stone, e.g. *Melia azedarach.*

**Sowing directly into pots**

For seeds which are large enough to be handled individually, and which usually have a good germination rate, direct sowing of one or more seed into pots is often the best method. A particular advantage of direct sowing is that root damage and root deformation, which can result from pricking-out, are avoided. Genera that are usually sown in this way include *Acacia, Lucaena, Balanites and Azadirachta.* Pots should be thoroughly watered on the evening of the day before and lightly again after sowing. After seed is sown, watering should only be done with a watering can that is fitted with a rose that has small holes and, therefore, delivers a fine water spray which does not cause soil erosion and possible seed displacement. This is especially important for smaller-seeded species where the seed is close to the surface.

The foremen use coarse water roses because watering is faster, and if it is done with shades or mulches these do help to reduce the erosive impact of coarse water sprays. After shades are removed, however, it is essential to use fine water sprays for germinating seeds and small seedlings. The seed should be sown in the centre of the tube at a depth equal to 2-3 times its smallest dimension, but in any case the top of the seed should be no more than 10 mm below the surface.

It is usually necessary to sow two or more seeds in each pot. The right number depends on the germination rate expected. It is wasteful to sow too many seeds and this also results in greater

thinning costs at a later date. As a general rule, sow 1-2 seeds per tube if field germination capacity (FGC) is expected to be over 80%, 2 seeds if germination is 60-80 %, and 3 seeds if germination is 40-60 %. Seed with less than 40% germination should be sown in seedbeds and pricked-out. If germination capacity is over 80% half the pots should be sown with 1 seed, the other half with 2 seeds. The extra seedlings can then be used to prick-out into any empty tubes. Some species, such as *Rhamnus prinoides (ghesho)*, are difficult to prick-out and should, therefore, be directly sown.

After germination there will be 0, 1, 2, or more seedlings in each pot. When germination is almost finished, prick-out plants from pots that have more than one seedling into pots without any germinant. This may still leave some pots with more than one seedling. If the extra seedlings are not removed, they must share the nutrients, moisture and light that are available for one pot and as a result inferior plants will be produced. During germination, twice daily watering is usually required, but as soon as roots penetrate a little into the soil it can be reduced to once per day.

Direct sowing is frequently also used for species with fine seed such as *eucalyptus* and *Casuarina.* The technique consists of first loosening the surface soil in the tubes, which is hard because it was previously compacted during pot filling. This loosening is done by careful digging to a limited depth with a wooden dibble or similar stick. Next, a "pinch" of seed held between thumb and forefinger is placed in the tube and the top stirred with a dibble or similar item. Sometimes a small amount of soil is also added to the pot after sowing.

If non-compacted tubes are used there is no need to dig up the surface of the potting mix, which creates an irregular surface not conducive to even germination. If the germination rate of the seed is known it can be appropriately diluted with fine sand or, preferably, with sawdust (sieved through a 2-mm mesh sieve). A practicable method is to carry out germination tests with a small volume of seed, and then to use the same volume for application of diluted seed to each pot. Simple arithmetic will indicate the degree of dilution required to obtain an average of 2-3 seedlings per tube.

**Sowing in seedbeds**

For preparation of seedbeds the essential requirements are good drainage, light texture, and absence of pests and pathogens. The sowing methods for seedbeds are similar to those used for seed trays, as described above. However, the use of sup-irrigation is more difficult with seedbeds and is not recommended. Also, because seedbeds are fixed, they are less flexible than seed trays which can easily be moved to make work more convenient.

Sowing of small-seeded species should be done by broadcasting not sowing in lines which is more wasteful of space and produces less uniform seedlings due to crowding along sowing lines. Larger-seeded species (for which seedbeds are not usually employed) should be sown individually in lines which are established running across the beds.

# MODULE 6: SEEDLING PRODUCTION

Seedlings can be raised in containers (pots or tubes), or as bare-root seedlings grown directly in the soil beds at the nursery site. Some species are better suited to grow in pots and others can be conveniently grown as bare-root seedlings, while many species can be raised by either system. There are many factors to consider when selecting the most appropriate system for raising seedlings of different species. It is important to consider the advantages and disadvantages of the two (potted or bare rooted) alternatives before deciding which to use.

## 6.1. Propagation

Trees are propagated either vegetative or from seeds. Seedlings can be collected from natural regeneration or artificially produced in the nursery. Those types of trees that can be propagated from coppices, root suckers etc. are the ones that can be reproduced naturally but producing seedlings from seeds in the nursery requires proper management and tending operations.

### 6.1.1 Seed propagation

The aim of seed propagation is usually to produce more plants. There are other methods of seedling productions such as the use of plant cuttings or root cuttings, but the use of seeds tends to be the most common. Seed propagation is a technique used all over the world.

Many people buy seeds they want to propagate in the same manner that they buy other gardening supplies. Some people collect the seeds from existing plants that they select for reproductions. The condition of the seed is very important because unhealthy seeds can produce unhealthy plants or may not grow at all. For this reason it is necessary to make sure the seeds obtained are not diseased or out-dated. There are also other factors that can have a negative effect on viability of seeds. One example is foreign origin seeds. Some seeds originated from one country may not be able to grow in certain other countries.

Another factor that plays a major role in seed propagation is the soil conditions. In order to be successful, the seeds generally need to be placed in soils that are well aerated and have good moisture. They need also to be placed at a depth that is conducive to their growth.

Despite all of the conditions, it is rare for seed propagation to have a 100 % success rate. In addition, there are some plants that can only be reproduced by seed and, on the contrary, there are some plants that cannot be reproduced by this method. Generally, seedlings can be grown in nurseries in 3 different ways

- From seed in plastic pots or as bare rooted;
- From cuttings, usually as bare rooted, or can be propagated; and
- Through direct sowing

**Potted seedlings**

During the past 20 years, the manual production of potted stock has been well-adapted in every region of Ethiopia. Potted seedlings have clear advantages.

**Advantages**

- The chain of seedling production is simple to teach to casual labour. Many stages of the work can be paid on a piece-rate basis and nursery management becomes simple;
- Potted seedlings can endure longer transport periods than bare rooted seedlings; the roots are not exposed to air drying during lifting, transporting and planting;
- Under Ethiopian climatic conditions and with difficult planting sites, the survival of potted seedlings is better than with bare rooted stock;
- The time in the nursery is usually less than for bare-root stock;
- They require less space in the nursery than bare-root seedlings of the same size;

- The availability of good soil at the nursery site is not an essential requirement as potting mix ingredients can be imported into the nursery;
- Soil-borne diseases are likely to spread more slowly than in bare-root seedlings;
- A longer planting period is possible than with bare-root seedlings; and
- Satisfactory results are possible with a relatively untrained planting labour force.

**Disadvantages**

- A great deal of soil is needed to fill the tubes and also a significant amount of soil must be transported with the pots;
- They require regular root-pruning in the nursery;
- They are heavy to transport and, consequently, reliable and timely transport to the reforestation site during the planting season is necessary;
- They are more complicated to raise seedlings especially if seeded in germination beds before pricking-out into tubes;
- The lack of availability of plastic tubes may be a bottleneck. Containers must be purchased; this will incur some cost and requires appreciable forward planning if they need to come from overseas;
- They are more expensive to produce than bare-root seedlings; and
- Foliage and shoot diseases are likely to be more severe due to closer spacing of seedlings resulting in higher air humidity.

The advantages, however, outweigh the disadvantages, and the final result is vigorous saplings in the field that grow into fully stocked stand.

**Bare rooted stock**

Bare rooted stock is not common in tropical countries. This method is better suited to temperate zones where seedlings have winter dormancy. During dormancy periods, seedlings can be transported easily, and they can also be stored temporarily at the planting site to wait for planting. In tropical climates, even the transport of bare rooted seedlings, let alone the storage, is difficult because of their non-dormant nature. Bare rooted stock, however, is cheaper to produce than potted stock. The method of bare rooted seedlings has not yet been fully exploited, and it is possible that it will have a future in the planting programs in the moist western regions of Ethiopia.

**Advantages**

- They are normally less complicated to grow in the nursery;
- They are not so heavy; therefore more seedlings can be loaded on a vehicle for transport to the plantation sites;
- Each planter can carry more seedlings to the planting site;
- They are well suited to mechanization, which is an advantage if labour costs are high;
- They are well suited to large centralized nurseries for economical seedling production; and
- They are cheaper to produce than potted seedlings.

**Disadvantages**

- They usually have a lower survival rate than potted seedlings when planted on unfavourable sites;
- The roots are susceptible to air drying during lifting, transporting and planting and therefore require more care and supervision during these operations;
- They require more space in the nursery than potted seedlings;
- They need a little more time in the nursery;
- They are more complicated to store at the planting site if, for any reason, planting cannot be done immediately;
- The nursery must have good soil conditions. It is especially important that the soil texture be light and that drainage is good;

- Planting time is more restricted than for potted seedlings; and
- Root diseases are more likely to become a problem because pathogen populations can build up during successive years of using the same soil.

Experience world-wide, indicates that in a semi-arid environment (i.e. with unreliable rainfall below 700 mm per year) survival and establishment is usually improved if containerized (not bare-rooted) seedlings are used. This is especially so if the bare-rooted seedlings are planted on poor soils where watering after planting is not practicable.

**Bare-root seedlings, stumps and wildings**
Bare-root, or open-root, seedlings are cheaper to produce and plant than stock grown in containers, but they also have numerous disadvantages. The main requirements for successfully using bare-root seedlings are favourable climate and soils, and the availability of reliable transport and labour for planting. These limitations make the use of bare-root stock of limited applicability. A few highland nurseries have grown *Eucalyptus globulus* and *Acacia saligna* as bare-root stock for use by individuals who are able to provide watering after planting. Some species like *Azadirachta indica* (neem) are often produced successfully as bare-root plants even in dry climates. Many aspects of growing bare-root plants are similar to production of container stock, but there are also some major differences.

Bare-root seedlings are grown directly in the soil present at the nursery site. Therefore, this soil must be of a suitable sandy loam texture and the site must be very well drained. If repeated crops of seedlings are envisaged, it will be necessary to add some compost, manure or chemical fertilizer annually to replace the nutrients removed with the seedlings. The soil must be cultivated to a depth of 30 cm and weeds should be eliminated.

**Plant density and area required*:***Plants should be grown in rows 20-25 cm apart, and spacing between seedlings should be 5-10 cm. The area required for bare-root seedlings is, therefore, much greater than that required for tubed seedlings. There should be 50-100 bare-root plants per square meter, compared to 100 per square meter with 10-cm diameter tubes.

**Sowing and pricking-out*:***Species with large seeds can be sown directly into beds, but for smaller-seeded species pricking-out (transplanting) is preferred. If direct sowing is used, it is important to thin seedlings to the required spacing of 5-10 cm between plants at an early age so that there is no undue competition.

If pricking-out is done, it should use similar methods to those described for tubed seedlings.
As there is more room in the open-root bed, it is possible to make larger holes for receiving the roots of the seedlings; therefore the roots can be slightly larger than those used in tubes. Seedlings with roots 5-10 cm long and shoots 3—5 cm tall are suitable for pricking out to produce bare-root stock.

**Root-pruning:**This is an essential operation which must be repeated several times during the growing period. Root-pruning can be done by inserting a spade at an angle of about 45 degrees and a distance of approximately 10 cm from the stem of the seedling and lifting slightly after inserting the spade into the soil. This must be done from both sides of the seedling to effectively cut or break roots which have become too long. In addition, insert the spade vertically between seedlings to cut roots that are growing along the direction of the row. This root-pruning should be repeated at intervals of about six weeks.

**Lifting and packing:**A spade or flat-pronged fork is inserted vertically about 10 cm from the seedling and pushed deep enough to permit lifting the plant with the majority of its root system intact. The soil is removed by carefully shaking the seedling, and any long roots are pruned with a sharp knife. After grading, which should include an assessment of the root system to ensure it is well developed and in balance with the size of the shoot, plants are packed. It is essential that the roots are not allowed to

become dry at any time, so work should be under shade as far as possible. Use of well-watered sacks, grasses, sawdust, etc helps to keep the roots moist and healthy.

After this, wrap the roots well in plastic bags to further reduce evaporation. Time taken before seedlings are planted should be as short as possible to minimize desiccation of seedlings. Unless seedlings are of very high quality, watering in any dry spell after planting may be essential to obtain satisfactory survival and establishment.

### Preparation of grass seedlings from seed

Grass seedlings are raised in a nursery the same way as bare rooted tree seedlings are raised. The seedlings are produced in raised seedbeds of 10m x 10m. The beds should be fine and firm to prevent burial/loss of seeds due to big clods and soil movement. In order to make fine seed beds, the clods should be thoroughly eliminated during seedbed preparation. The seedbeds prepared in dry weather conditions could easily be destabilized and the seeds could be buried because of the movement of dry soil.

To avoid the possibility of burying the seeds, the seedbeds prepared in dry weather should be watered one day before planting. This activity stabilizes the seedbeds and avoids the burying of seeds due to soil movement. The seed is then broadcast on the seedbed the same way described for the establishment of grass strips by broadcasting. The seedling should be properly watered and weeded while in the nursery. It nearly takes three months before the seedlings are ready for field planting. The seedlings should be carefully uprooted and handled during planting. Only those seedlings that can be planted on the same day should be uprooted in one day. The uprooted seedlings should be covered with mulches or stored under shade before planting.

## 6.2 Vegetative propagation

Vegetative propagation is the production of new plants directly from vegetative parts of existing ones, not from seeds. There are numerous methods of vegetative propagation including cuttings, layering, division and grafting. The techniques involved in vegetative propagation are usually more technical than propagations using seeds.

Vegetative, or asexual, propagation is used to produce a plant identical in genotype with the source (mother) plant. This is in contrast to propagation from seed where every individual has a different genotype and may, therefore, have properties quite different from the mother plant. Vegetative reproduction is the production of new plants directly from vegetative parts of existing plants.There are four broad categories of methods which can be used in vegetative reproduction:

**Cuttings and layers**
This is a method in which new roots and shoots are developed on sections of shoot, root or leaves taken from the mother plant.

**Grafting and budding**
This is a method in which the root system of one plant is joined with the shoot of another plant to form a single composite plant, which in effect has two genotypes.

**Division and separation**
This is a method in which naturally formed special vegetative structures such as rhizomes, runners, suckers, tubers, bulbs, corms, or bulbils, are used to produce new plants.

**Micro propagation**
This method (also known as "tissue culture" or "in-vitro culture") is a relatively new technique in which new plants are produced from very small structures (embryos, shoot tips, meristems) in aseptic cultures. The method requires considerable technical expertise and equipment but has great potential

to produce very large numbers of identical seedlings. It is now used in several counties for establishment of extensive commercial forest plantations with genera such as *Eucalyptus, Pinus* and *Populus.* Associated with micro propagation are techniques of *genetic engineering* which enable further improvements in producing genotypes which have desired *ecological* and *commercial* properties. Such technologies have become an important aspect of modern plant propagation and breeding and are included in the term "*biotechnology*".

**Reasons for using vegetative propagation**

Seed is not always available, germination of some seeds is difficult, or successful nursery techniques for a given species (seed) have not been developed;

- An individual mature plant may exhibit very desirable features (e.g. fast growth rate, disease resistance, drought or salinity tolerance, abundant fruit etc) which are genetically determined;
- Multiplication of such individuals, maintaining the exact genotype of the mother plant, is possible only with vegetative reproduction. These genetically identical individuals form a "clone". Cloning thus provides for multiplication of specific selected genotypes;
- The members of the clone should all exhibit the desirable features of the mother plant if they are grown in a similar environment. This represents a much faster method of genetic improvement than is possible through conventional breeding programs based on sexual reproduction and growing successive generations from seed;
- Fruit trees will have the superior quality and quantity of fruit that is evident in the mother tree;
- The age at which fruit trees start to bear fruit is reduced. In general, vegetative reproduction results in earlier maturity;
- It helps to combine the advantageous qualities of two plants by grafting or budding. For example, this enables the shoot to be from a tree which produces a high yield of quality fruit while the root system comes from a tree that is vigorous and disease resistant. This is the reason why the majority of fruit trees in temperate countries are reproduced by vegetative methods;
- In contrast, the majorities of fruit trees in tropical countries are still of seedling origin, and hence often have reduced quality and quantity of fruit;
- Artificial hybrids between two species may have good commercial properties but their seed is often sterile. Vegetative propagation may offer the only practicable method for multiplication of such hybrids; and
- If micro-propagation is used, a large supply of planting material can be produced in a short time from very little mother plant tissue.

There are also disadvantages which may be associated with vegetative reproduction:

- Disease transmission is often associated with vegetative methods. This is especially relevant for viral pathogens which are transmitted through sap. Viruses are relatively rare in forest trees but are quite common in fruit trees. This problem of pathogen transmission, especially with grafting or budding, can be reduced by ensuring that only specially selected pathogen-free mother trees are used.
- Genetic uniformity within monoclonal plantations can lead to uniform susceptibility to insects, diseases or other environmental hazards. Such a monoculture can be particularly vulnerable to the introduction of a new pest or pathogen into the locality, and it might result in extensive losses of plants.
- The technical skill and equipment required to effectively implement vegetative propagation is often greater than that required for propagation from seed.

**Cuttings (Vegetative propagation)**

Cuttings are sections of stems, roots, branches, leaves or twigs gathered from suitable mother trees or shrubs. They are placed with part of their length in a suitable rooting medium to induce the formation of new roots at the basal end and the development of leaves and shoots on the upper portion. A cutting thus grows into a new individual plant which is a clone of the mother plant.

Cuttings are the most important means of propagating ornamental trees and shrubs, deciduous as well as evergreen species. For species that can be propagated easily by cuttings, this method has numerous advantages. Many new plants can be produced in a limited space from a few mother plants. The method is inexpensive, rapid and simple and does not require the special techniques required for grafting, budding or micro propagation. There is no problem of incompatibility with rootstock or of poor graft unions. Greater uniformity is obtained by absence of the variation which sometimes appears as a result of the variable seedling rootstocks of grafted plants. Among the grasses, elephant grass is propagated by cuttings.

There are several types of cuttings, which are classified according to the part of the plant from which the parts were obtained. These are: stem cuttings, stem cuttings are further subdivided into hardwood, semi-hardwood, softwood and herbaceous, root cuttings and leaf cuttings.

Cuttings are grown in special beds called propagation beds. Propagation beds for cuttings have to provide excellent environmental conditions that are not only favourable for the formation of new roots, but also for all other life processes within the newly developing plant. The most important environmental factors for successfully growing (striking) cuttings are proper soil aeration (good oxygen supply), adequate moisture content of the rooting medium, as well as a high humidity of the atmosphere, good light conditions and a favourable soil and air temperature. After root growth is initiated, it is also important that there are sufficient nutrients available to enable continued root and shoot growth.

## 6.3. Direct sowing

Direct seeding establishes trees, shrubs, and under storey plants by sowing seed directly onto the site to be re-vegetated. Whether it is sowing by machine or by hand, a good site preparation and effective weed control are essential for the success.

### 6.3.1 Advantages

The advantages of direct seeding over seedling planting are many:

- Direct seeding is much cheaper (10 - 20% or less of the cost of planting tube stock), and requires minimal labour.
- Existing farm equipment can be used.
- Higher plant density after germination provides better shelter to new seedlings and reduces weed competition. It also allows natural selection to sort out the stronger from the weaker plants without creating gaps to be replanted.
- Plants are able to “self-select” suitable establishment sites within the re-vegetation area, particularly if a mixture of species is sown.
- The plants are usually healthier and have stronger, deeper root systems because they are not transplanted and there is no disturbance to root growth. This enables plants to be more tolerant of stressful conditions such as pest attack and drought.
- Final plant cover is random, and looks more natural than planting.
- Little maintenance is required after plants are established, apart from ongoing weed control for at least the first season.

### 6.3.2 Disadvantages

The disadvantages of direct seeding are:

- Direct seeding is limited to plants that grow readily from seed;
- A large amount of seed is required. Hence, if only minimal seed is available for a particular species, it may be better to raise seedlings for that species in a nursery;
- Plants germinating under field conditions are extremely vulnerable. Frosts, spring droughts, or flooding of the sowed area can dramatically reduce seedling establishment; and
- The initial density of plants is harder to control. This may create undesirable spacing for quality timber production, but can be overcome by “spot” sowing.

### 6.3.3 Uses for direct seeding

Direct seeding is suited to re-vegetate large areas for:

- Conservation structures on farmlands such as soil bunds, gully and fanyaa-juu;
- Rehabilitation of gullies and degraded areas; and

## 6.4. Production of grass splits and cuttings

### 6.4.1 Production of elephant grass and bana grass

Elephant grass can be reproduced by seed; however, seed yield of elephant grass is usually very low,less than 1-2 kg/ha pure germinating seed. Because of low genetic stability and viability, elephant grass is normally propagated from stem cuttings or root splits. Root splits generally take more labour to prepare (uproot) and to plant but result in quicker establishment. Splits are planted like normal seedlings. Using cuttings is the cheapest method of establishing elephant/bana grasses

When using cuttings, two nodes should be covered with soil and one node left exposed. Cuttings are planted at an angle of $30\text{-}45^0$. Cuttings can also be planted horizontally into a furrow, to a depth of 15-20 cm. One hectare of elephant grass can provide propagating material enough for 15-25 hectares.Normally splits/cuttings are planted in rows or trenches 0.25-0.5 m apart. Distance between rows is 0.4-1 m.

### 6.4.2 Production of Vetiver

Vetiver rarely produces seed. Hence, the only reproduction method is through asexual means. Several vegetative propagation methods are available throughout the world:a) using tillers: a shoots growing from the base of the stem of the plant, b) using a clum: bunch of tillers and c) using plantlet: differentiated tiny plant developed through tissue culture technique.

Tillers are shoots growing from the base of the stem of the plant. It is the most popular part of the plant used in propagation. Propagation in our country is commonly made using tillers. Tillers are available in large quantity, convenient and are economical.Production of bare rooted seedling is the most common multiplication method that is widely practiced in our country. The most important steps are as follows:

- Prepare the land intended for multiplication: Water the plot the thoroughly before planting, Prepare open furrows, add compost or chemical fertilizer at the bottom before planting
- Prepare the planting material. After Collecting the clump form dependable sources (fully matured, 4 months old clump), divide the clumps in to smaller tillers, when dividing into tillers, it would be advisable to separate where they tear best to avoid damages. Then trim the shoots and roots to the length of 20 and 10 cm receptively and soak the tillers in water for one day. Next bind the tillers together in to bundle, cover them with jute sacks and spray water every morning to moisten it for about 5-7 days until they develop roots.
- Planting. Plant two to three tillers per station along plating furrows. Tillers should be placed in double rows at 40 cm spacing between the plant and between rows.

Assuming a spacing of 40x40cm between plant and rows respectively, In 0.16 $m^2$ area, we will have four stations and in 1 hectare there will be 62500 station or clumps. Each clump, if managed well, can produce 40-50 (Average 45) tillers after 4-5 months. Hence, 62500 clumps has 2,812,500 tillers. This is enough for nearly 281 km of soil bund or Fanya-Juu.

### 6.4.3 Production of Desho grass

Desho grass can set seed but is usually established by splits. Propagating by splits have high survival rates and establishes better than grasses which are seeded. The production of desho grass is similar to desho grass.Splits are usually planted at a distance of 0.40 cm x 0.40 cm in a nursery.After 3-6 months (depending on management), one split planted can produce 20-50 splits.

## 6.5 Quality seedlings

Once a nursery is established, there are many management considerations relevant to the effective and economical production of quality seedlings. Nursery management can be viewed as the day-today activities which are performed within an annual time frame to produce maximum number of quality seedlings in the most economical way. In order to effectively manage a nursery, the nursery manager must have a clear idea of what type of planting stock the nursery should produce at the end.

The kind of high-quality drought-resistant seedlings that should be produced at the end can be conveniently termed as "target seedlings". Such target seedlings have qualities that give them a high probability of survival after planting and good growth rates after establishment.
The desirable characteristics of drought-resistant target seedlings can be specified as follows:

1. Seedling height is approximately twice the height of the container;
2. The root-collar (or stem diameter at soil level) should be thick in relation to the height resulting in a sturdy seedling;
3. The root system should be well developed with an abundance of fine fibrous roots penetrating the whole volume of the container. This will help to produce seedlings with a good root/shoot ratio;
4. There should be minimal development of roots beyond the container, and a vigorous taproot should not be allowed to grow below the container.
5. The seedlings should be adequately hardened-off so that by the time they are planted out they will be adapted to conditions of full sunshine and moisture stress as well as low humidity and increased wind;
6. The appropriate microbial symbionts should be present on the root system. This implies the following for three different taxa of plant species:
   a) *Most legumes:* should have macroscopically visible nodules formed by symbiosis with *Rhizobium* bacteria, thus allowing nitrogen fixation. The presence of appropriate mycorrhizae will further improve nutrient absorption and drought resistance.
   b) *Casuarina:* should have macroscopically visible nodules formed by the Actinomycete known as *Frankia.* This will allow symbiotic nitrogen fixation which would otherwise does not occur. Again, the presence of mycorrhizae is beneficial to further stimulate growth and drought resistance.
7. The seedlings should have desirable physiological characteristics, including the following:
   a) High root-growth potential after planting;
   b) Adequate starch and other food reserves in both stem and roots;
   c) An adequate nutrient so there is no deficiency in either macro- or micronutrients, nor an imbalance in their proportions;
   d) Resistance to water logging. This can be important if heavy rains follow planting, causing planting pits to become saturated. Larger plants are more tolerant of water logging;
8. The root system should not have spiralling roots or other deformities which can lead to problems after several years.

As far as possible, the target seedlings should possess all the above seven characteristics of a quality seedling. To achieve this is the primary task of nursery management. Good supervision is essential to the successful management of a nursery and requires good communication at all levels. Good supervision costs little more than poor supervision but can have a profound influence on the quality of the seedlings produced.

# MODULE 7: NURSERY TENDING AND PROTECTION

## 7.1 Tending operation

Appropriate care of seedlings in the nursery is crucial for seedlingsurvival and growth after outplanting. Important maintenance activities forseedlings in the nursery include mulching, shading, watering, pricking-out, thinning, root pruning, weeding and hardening off.The major techniques are describes as follows:

### 7.1.1. Mulching

Mulching is a protective covering of seeds by grass or locally available materials to prevent the evaporation of moisture, the freezing of roots, and the growth of weeds. Immediately after sowing, mulching of the seedbed is done to protect the seeds from being washed away during watering and to reduce evaporation and conserve moisture. Grass mulch or locally available materials are used as a blanket for the germinating seeds. Fresh straw and grass used for covering sown pots may introduce weed seeds, which will germinate under the favourable moisture conditions. Therefore, efforts should be made to minimize the introduction of weed seed with the mulching material.

### 7.1.2 Shading

Seedlings in the early stage of their development, particularly from sowing to immediately after picking out are sensitive to full sunlight, high temperatures, heavy rains and strong winds. Therefore, they should be protected by shading, which is constructed from local materials i.e. branches, grasses, etc. When seedlings are more resistant, shading is reduced gradually from all day to around mid- day, and later to none at all. Shades could be constructed in removable forms for ease of management. Shades reduce the day-time temperature and the rate of evaporation from soil and plants beneath them. The humidity around the plants is also increased.

Shades should be 1.3 m wide to provide some overlap at the edge of the beds so that the "edge effect" is minimized. The use of shading is often poorly managed; shades are often too dense (allowing about 5-10% of sunlight to penetrate), left on for too long, or left on at the wrong time.

Shading can be low or high. Low shades are most common in highland nurseries. They are temporary, made of local material, cheap to erect, but they require plenty of manual labor support for low shades can be made of bamboo poles. The cover is spread on the supports only 30 to 50cm above the ground. Low shades are adjustable: as the seedlings grow bigger the shades are lifted by changing the supports in to longer ones. Low shades have a disadvantage in that the shading mats or screens have to be removed to water or weed the pots. Water applied on top of the mats or screens may seep down to the seedlings as heavy drops that do not water the pots evenly and may even compact the soil.

High shades are elevated enough so that a labourer can move freely below them. High shades are usually constructed as a permanent installation. They are built of poles or wooden posts about 2m apart and connected at the top by longitudinal beams and cross beams. When seedlings are shaded, shading mats or screens are placed on top of the scaffolding. High shades are not commonly used in Ethiopia.

Shading mats, both for low and high shades can be locally made from bamboo slats. Local shading mats can be prepared by the nursery staff during the silent nursery season. Bamboo is cut into pieces of about 1.20 m in length since the shading mat should be slightly wider than the standard nursery bed. The bamboo poles are split lengthwise into slats of 15 to 20mm wide.
The slats are then connected with wire or string, and some space is left between each slat. The width of the slats and the space left between determines the degree of shading the mats provide. A mat made of 20mm wide slats with spacing between 20mm permits 50% light to pass through. If the stretches between the slats are reduced to 10mm, shading rises to 67%. Handmade shading mats should not exceed a length of 5m since longer mats are heavy and inconvenient to handle. Shading mats of a suitable length can be spread easily and quickly rolled up when required.

Shade makes conditions more uniform throughout the 24 hours of the day. It also reduces light reaching the plants and thus can decrease photosynthesis to unacceptably low levels if the shade is too dense. If shades are left on too long or are too dense this encourages the growth of tall, thin, weak (etiolated) plants which may even have lost their healthy green colour and become yellowish (chlorotic). The plants will also have low food reserves, which results in slower root regeneration after planting. Such plants, which have been growing under comparatively cool, humid conditions and low light intensity in the nursery, are subject to severe shock when they are planted out, especially if subjected to hot or dry conditions. Their chances of survival will be much reduced.

Besides the adverse effects of shade on seedling quality mentioned above, shade also has a large influence on disease development. Most fungal diseases thrive in conditions of high shade intensity, which result in high air humidity and longer periods of surface wetness of plant tissues. Excessive shade, therefore, tends to encourage many diseases. Heavy textured potting mixes are especially conducive to root rot**,** and high levels of shade further increase the severity of disease.

The adverse effects of excessive shade can often be clearly seen in nurseries because the healthiest seedlings are evident at the edges of pot beds where they receive relatively more light than the central part of the bed (the edge effect). There is often a consistent gradient from thicker-stemmed, taller, healthy green seedlings at the edges of pot beds to thinner, shorter, chlorotic seedlings at the centre of the bed. In many instances this is the result of excessive shade application. The central seedlings also have a poorer root system, which is an inevitable result of high shading intensity. Consequently the root/shoot ratio will be low and field survival can be expected to be lower than for seedlings raised with plenty of sunshine. In spite of the above negative consequences of shading, there are situations in the nursery when the use of shade is appropriate.

### 7.1.3 Watering

An ample supply of water is essential for a well-operating nursery. The water must be of good quality. It should be clean, the pH value should range from neutral or slightly acidic (5.5 to 6.5) and there should not be too much slat in it. Newly sown seed must not be allowed to dry out at any time as this would kill many germinating seeds, especially when the radicles are just starting to emerge. To maintain moist conditions it is usually necessary to water at least twice a day. If fine sand, which dries out quickly, is used to cover the seed, more frequent watering might be required. If sown seed are not shaded they will also require more frequent watering, and weather factors will obviously have a major effect on rate of drying of seedbeds. Larger seed, which are sown deeper, will be less liable to rapid drying than smaller seeds which are sown with only a thin covering of sand. The seed germination medium should not be too wet as this causes problems with aeration and damping-off. The experience of the foreman and a well-drained germination mix are essential to ensure that there is adequate but not excessive moisture during germination.

The watering of germinating seed and young seedlings must be done with a watering can which has a hose with very fine holes so that it produces a fine water spray which does not disturb the germinating seeds and their short, delicate root systems. When such fine hoses for watering cans are often not available, the usual practice is to water with shades in place to break the force of an erosive coarse water spray.

This is moderately effective in reducing erosion caused by the water spray. It is also difficult to visually assess the relative dryness of soil when shades are in place, and uniform watering of the whole bed is, therefore, more difficult. Shades also cause a degree of unevenness in watering because they tend to concentrate water along drip lines created by the grass stalks. It is therefore important that all nurseries have sufficient fine hoses to enable watering of young seedlings without shades in place. The best fine spray is achieved by a watering can which has the rose with fine holes pointing upwards, so that a very gentle spray that settles with minimum velocity is produced.

As seedlings grow progressively larger in the presence of adequate sunlight, they rapidly develop roots into the lower portions of the potting mix, after which watering can be decreased to once per

day. Seedlings with 2-3-m long shoots should have a sufficiently well-developed root system to require watering only once a day. Even if the surface of the tube appears dry, lifting the tube will indicate that there is moisture available in the root zone of even quite small seedlings. Excessive watering is often indicated by abundant growth of algae at the top and sides of tubes, which develop a green colour as a result. Watering should be done late in the afternoon or early in the morning to minimize evaporation losses and to prevent leaf scalding, which can occur if seedlings are watered in strong sunlight. If fungal diseases are a problem, it is best to water in the morning as any excess moisture will be quickly evaporated. If watering is done late in the afternoon, high moisture levels conducive to disease are likely to be maintained for more time during the night thus leading to increased disease severity.

When seedlings are growing well, it is essential that watering is sufficient to wet the potting mix in the whole length of the tube. This may require several watering, allowing a few minutes for the water to infiltrate the potting mix before watering again. If only the top of the tube is moistened there will be very little root growth in the lower levels of the soil mix as they are likely to be too dry. This is particularly relevant when using the longer (20-cm) tubes. However, even with 15-cm long tubes it is common to find tubes with larger seedlings, which after routine watering, do only have the top 5 cm of soil moistened. Frequent light watering (insufficient watering) not only restricts root development but is also a waste of water because a high proportion of water lost by evaporation from the soil surface. This also causes more rapid salt accumulation as salts are left at the upper part of the root zone after water evaporated.

Thus, it is more economical and conducive for a better root development within the whole volume of the tube if watering is thorough but less frequent. The foreman should lift a number of tubes at random to examine how far the water infiltrated and make sure watering is continued until the whole tube depth moistened. Watering is essential immediately after root-pruning to help the seedling overcome the shock of losing part of its root system and to encourage growth of new fibrous roots. Unless there is watering immediately after root-pruning, it is obvious seedlings tend to wilt quickly. Thus, watering of seedlings before final dispatch to planting sites should be very thorough to ensure that the seedling has the maximum available moisture reserves within its tube. Such moisture reserve can be critical for survival if dry weather follows after planting in the field.

### 7.1.4 Pricking-out

If seeds have not been sown directly into pots, pricking-out (also known as transplanting) must always be done. The aim of pricking-out is to establish a single vigorous seedling, centrally placed in each pot, with minimal disturbance to continued growth of the seedling. When pricking-out, one of the most critical things is to use a size of seedling that is most likely to survive. If a seedling is too large, it is difficult to lift it out with the majority of its roots intact, or to place this large root system in the new pot without distortion to the roots. If a seedling is too small, it is very delicate and may have an inadequate length of root.

In practice the hole made for receiving a new seedling should be about 5 cm deep and 1-1.5 cm in diameter. The correct size of seedling for transplanting should, therefore, be judged primarily by the length of the roots, which should be about 5 cm long, rather than by the height of the shoot. Usually the shoots of seedlings suitable for pricking-out have 2-4 leaves besides the cotyledons. If the roots are approximately 5-cm long, many potential problems associated with pricking-out can be avoided. These include:

- A seedling with 5-cm long roots can be easily lifted with minimal loss of roots;
- Such a small root system does not require any root-pruning before it can be placed in the new tube; and
- Such a small root system can be easily placed into its new position with little chance of root deformation and distortion. Avoiding root deformation is very important as it can cause permanently deformed root systems, which can in turn lead to death of the plant several years after planting. This potential for root deformation is a major disadvantage of the pricking-out method of growing seedlings.

It is an advantage if the seedlings to be used for pricking-out are relatively hard. This is primarily achieved by ensuring that they receive as much sunlight as they can tolerate, starting immediately after germination. This helps to produce relatively robust seedlings with thicker stems that are less easily damaged by handling with fingers. Most importantly, such seedlings with previous exposure to high levels of sunlight have more vigorous roots and some ability to limit excessive water loss from the shoot by transpiration. They, therefore, have a better chance of surviving the shock of pricking-out than thin, weak seedlings such as those produced under dense shading.

Pricking-out is a delicate operation which should be done with great care, preferably by workers with previous experience. It is best if the whole transplanting operation can be done under shade, which can be provided by having a moveable shade to protect both seedlings and workers. If this is not possible, pricking-out should be restricted to the coolest times of the day, such as early morning and late afternoon. Cloudy days with little wind are especially suitable for pricking-out, and on such days this operation can be done throughout the whole day. Encourage workers doing the pricking-out to discard any seedlings which do not have a relatively well-developed root system when judged in relation to the shoot. Some seedlings are genetically predisposed to having relatively poor roots and the sooner such plants are eliminated from routine operations is the better. Even if they survive in the nursery for several months, they have a low chance of survival after planting.

If the good techniques described above are followed, it should be possible to achieve over 80% survival. Some nurseries do in fact achieve such good results, but many experience significant losses after pricking-out and typically have survival below 50%. The most common causes of mortality following pricking-out are:

- Drying out of the roots in the time between lifting and replanting;
- Leaving air pockets around the roots instead of ensuring that the roots are in close contact with the soil;
- Waiting until seedlings are too large before transplanting. Then it is difficult to remove sufficient roots to maintain a satisfactory root/shoot ratio;
- Pulling seedlings out of the soil without the use of a dibble stick to help remove roots intact;
- If seedlings are pulled out, it is common for this to result in the seedlings having only a taproot and no lateral roots. In addition, the force required to pull the seedling frequently causes mechanical stem damage, which in turn predisposes the plant to disease;
- Making a planting hole that is too shallow so the seedling is not planted deep enough. If roots are exposed to air, they dry out rapidly and the seedling dies. Shallow holes also promote root deformation;
- Making a planting hole that is too deep, resulting in the plant stem being partly buried, with consequent greater chance of stem disease, especially if soils become too wet;
- Existence of extremely hot, sunny or windy weather condition especially if shading is ineffective;
- Too little or too much watering. Excessive watering is especially a problem in heavy-textured soils where root-rot disease is also likely to become important. Too little watering is more likely when the potting mix is very well drained due to a sandy texture;
- Leaving dense shades in place for too long; and
- Since the growth of seedlings varies with altitude and rainfall, each nursery must determine - species by species the time needed between sowing and seedlings reaching planting size.

### 7.1.5 Weeding

Competition from weeds for nutrients, light and moisture depresses seedling growth and can, if not controlled, lead to seedling deaths. The competition for nutrients is especially critical in nurseries as potting mixes contain only limited nutrients and symptoms of deficiency are common. Competition for light is only important if weeds are allowed to grow unchecked and become large. Likewise, competition for moisture increases as weeds increase in size, so the aim should be to eliminate weeds while they are still small. Weeds can also encourage some pests and diseases.

Weeds propagate either by seeds or by underground rhizomes and stems. Special attention must be given to weeds with underground propagation. These are more difficult to eradicate, and they should be removed with their rhizomes as soon as they appear. Construction of a wind breaks around the nursery and hedges around the compartments decreases weed infestation by wind. Cutting adjacent grassland before the grasses flower decreases the spread of grass seed. Rhizome-infested nursery compartments must be cleaned annually to remove all rhizomes before the nursery beds are laid out. Compost and manure should be allowed to decompose well over a long period. An inside compost temperature of about 70 degrees Celsius kills most of the weed seeds.

In Ethiopia labour is still cheap and hand weeding is usually still the most appropriate way to control weeds. Various chemicals (herbicides)) can be used to spray weeds and kill them (e.g. glyphosate, trade name "Roundup") but they are expensive and require exact methods of application. There is always the possibility of spray drifting onto tree seedlings and causing damage. There is also a risk to health of workers if safety precautions are not strictly followed.

If application of herbicides is contemplated, then the following considerations must be taken into account:

- Likelihood of damage to tree seedlings from the herbicide formulation;
- Correct concentrations and dosage rates;
- Timing of herbicide application;
- Prevailing weather conditions; and
- A safe method of application to ensure the workers' health is not affected.

Despite these limitations for using chemical weed killers, they are useful for control of weeds which produce rhizomes or underground stems and which are therefore difficult to eliminate by simply digging the plant out. Where such weeds occur within seedbeds or pot beds, they can be sprayed with Roundup when the beds are empty. Spot spraying of individual weeds is all that is required. If this is done, it obviates the need for digging up whole pot beds annually to control weeds. If weeds growing up from the base of pot beds are a problem, then placing a strong sheet of black plastic under the pots is also an option. This plastic sheeting has the dual benefit of preventing taproot growth below the tubes and therefore reduces root-pruning costs.

If it is anticipated that there will be a large number of weeds in the germination or potting mix, it is advisable to pre-germinate them. This can be achieved by watering pots and seedbeds for several weeks before sowing. The weeds can then be killed by stopping watering and letting them die from drought. Alternatively, they can be sprayed with herbicide or removed by hand before sowing when they can still be relatively easy to remove.

It is best to remove weeds while they are still small because this minimizes their adverse effects on tree seedlings due to competition, and it is also easier and cheaper to remove weeds while they are still small. If weeds are allowed to grow large they develop large roots which are difficult to remove and also more likely to result in root disturbance of the tree seedlings. The potting mix should be moist when weeding to enable easier removal of roots. A pointed stick, dibble, flattened piece of wire or similar tool can help to remove weeds with their roots so that they do not grow again.

If there is crusting of the soil surface in pots, this is a good time to combine cultivation of the surface with removal of weeds. Weeding must be done repeatedly - at intervals of about two weeks when seedlings are small, but at longer intervals as the seedlings become larger, weeds tend to be suppressed and fewer weeds are germinating. Frequent inspection by the foreman will indicate when and where weeding is required, and this can vary widely between nurseries and seasons.

### 7.1.6 Thinning the stand

Once seedlings are several centimeters tall, there should only be a single seedling per tube to minimize between-seedling competition. While weeding, it is also a convenient time to thin the tree

seedlings if this has not been previously done. Only a single, healthy, centrally placed seedling should be left in direct-sown pots, which initially often have several seedlings.

### 7.1.7 Root pruning

A good root system, with a well-developed mass of fine feeder roots, is an essential feature of quality "target seedlings" we want to grow. It should be emphasized that a good root system of the right size is the single most important factor in determining a good survival rate of the seedling at the reforestation site.

Root-pruning of tubed seedlings is an essential operation that should be an integral part of good nursery management. The purpose of root-pruning is to:

- Prevent the development of a taproot system outside the tubes;
- Encourage the growth of a compact, fibrous root system within the tube with many active rootlets that are able to absorb water and nutrients;
- Maintain a favourable root/shoot ratio (the higher the better); and
- Produce sturdy seedlings that have a thick stem diameter relative to their height.

After germination, many species in nurseries quickly develop a taproot that grows vertically downwards within the tube. *Acacia* and other drought-resistant species such as *Leucaena* are particularly able to develop a taproot very quickly. If tubed seedlings are not root-pruned, the roots will extend into the soil below the tubes constituting the base of the pot bed. This extended root system supports fast development of a succulent, soft, shoot system. The result of this is that a substantial portion of the root system will remain in the nursery bed after removing seedlings at planting time. The roots remaining within the tube are often only a short section of woody taproot that has few lateral roots. Such un-pruned seedlings have a low root/shoot ratio. The relatively few roots remaining within the tube are then insufficient to supply this once vigorous seedling with enough water to prevent wilting, and possibly death, after planting.

Often the problem with unprunned seedlings is not apparent while seedlings are still in the nursery. In fact, to the casual observer, a tall and "soft" seedling resulting from inadequate root pruning may look better than a smaller, quality, seedling that has been consistently root pruned. Regular root-pruning should prevent the growth of a taproot below the bottom of the tube. It also results in the formation of a more branched root system, with many small active rootlets within the tube. Whenever a seedling is root-pruned there is a physiological response by the plant to regenerate new lateral rootlets above the point where the roots were cut (i.e. within the tube). Root-pruning, therefore, increases the root/shoot ratio, and in particular the proportion of fine roots compared to woody roots. Root-pruning also helps to limit height growth of seedlings but encourages diameter growth of the stem, so producing more sturdy seedlings, which is an important desirable character of target seedlings.

Seedlings should be root-pruned for the first time when the taproot has emerged from the base of the tube and is no more than 1 mm thick. The time required for the seedling to grow to this point varies greatly depending on the species, and may be as soon as 6 weeks after germination. The foreman must periodically lift tubes at random to determine the extent of root growth and then begin root-pruning accordingly. After the initial root-pruning, another taproot will develop with time, so repeated root-pruning is necessary at intervals of 2-4 weeks, depending on species. The final root-pruning should be made about 2 weeks before the anticipated planting date, which should allow further new rootlets to regenerate before planting. A thick, strong, taproot several millimetres in diameter should never be allowed to develop below the tube.

Repeated root-pruning is a labour-intensive task, and this is one reason why insufficient pruning is done in many nurseries. As mentioned previously, the correct sowing date is critical to minimize the number of root-pruning that will be needed. Sowing too early will, of course, increase the number of root-pruning required.

Root-pruning, if done at the correct stage of seedling growth, often results in subsequent slight wilting of the seedlings. Hence, in order to avoid this problem, it should be done on cloudy days or late in the afternoon. It is also best if the potting mix is moist at the time of pruning but not so moist that soil loss from tubes occurs when lifting the seedlings. After pruning, the seedlings should be thoroughly watered to help them recover after the shock of losing part of the root system. If for some reason root-pruning has been unduly delayed, there might be severe wilting and it may be necessary to shade the seedlings to help them recover.

### 7.1.7 Hardening-off

In a well-managed nursery, seedlings grow under favourable conditions and with continuous care. They are sheltered from excess sun and dry season winds, they are regularly watered, and they are even fertilized according to their needs. By contrast, the plants are often subjected to extremely difficult conditions when they are planted out. The most likely situation is that seedlings will experience severe moisture stress and increased heat stress after planting. This can be caused by a lack of rainfall after planting, as well as increased wind, sunshine and lower relative humidity in plantations. Management of the seedlings in the nursery must be designed to accustom them to, and be able to tolerate, these difficult conditions before they are planted. This is done by the process known as "hardening-off". Hardening-off is the process of gradually increasing the moisture and heat stress to which seedlings are subjected. The aim is eventually to create in the artificially controlled environment of the nursery conditions similar to those that will be experienced by the seedlings in the natural environment of the plantation.

Hardening-off should start at least four weeks before planting is anticipated, which in most of Ethiopia starts in July. Therefore, hardening-off should start in early June at the latest, and if possible in mid-May. After starting hardening there should not be any significant increase in height of seedlings, but their diameter should continue to increase. At the completion of hardening the seedlings should have well-lignified tissues; the leaves should have a thick cuticle and be hard and leathery; the stem should be brown, not green, and as thick as possible; and there should be a much-branched fine root system within the tube with no evidence of recent taproot growth below the tube. The essential actions needed to induce hardening-off in seedlings are described below.

**Removal of shade**

In previous sections it has been suggested that shading should only be required during germination and after pricking-out. The majority of the seedlings' life in the nursery should therefore be under conditions of full sunshine. If for any reason, however, seedlings are still shaded when planting time is approaching, urgent action must be taken to reduce the shading in gradual steps. This gradual removal of shade is critical because if seedlings go from 90% shade to sudden full sunshine there is insufficient time for them to adapt to the sudden severe conditions, resulting in appreciable mortality. For at least the last month in the nursery seedlings must be exposed to full sunshine, even in the lowlands.

**Root-pruning**

Even if there has been little root-pruning in the early stages of the seedlings' growth, it is essential that root-pruning is carried out during the weeks of hardening-off. If a taproot grows below the tube, a seedling continues rapid growth and produces "soft" shoots, which make it impossible to adequately harden-off. Thus, final root-pruning should be made about two weeks before planting is anticipated.

**Reduction of watering**

The watering frequency must be gradually reduced so that physiological changes can occur in the seedlings in response to the imposed water stress. After watering, the foreman must observe the seedlings closely for the first signs of wilting before watering again. This cycle of watering and then waiting until seedlings start to wilt is repeated, waiting a little longer before re-watering with each successive cycle. It is important to not wait too long before watering again as seedling death may occur if wilting is allowed to continue for too long. This requirement to apply sufficient moisture stress to induce hardening without also causing significant mortality is a delicate balance, and requires good judgment from an experienced foreman. In this manner, seedlings gradually develop appropriate

morphological and physiological characteristics and become accustomed to water stress. The development of a thicker leaf cuticle, which reduces water loss from wilted leaves, is one very important consequence of hardening-off.

## 7.2 Protection: pests and diseases

A nursery place is a place which can be a source for numerous categories of destructive agents. Seed, germinating seed, and seedlings (up to the time of dispatch) might be used as a food source by many biological agents. In the process of using the seedlings for food, considerable damage can be inflicted. Loss in vigour and mortality of seedlings are possible. There is also distinct possibility that some harmful agents such as fungi and insects can be dispersed with the nursery seedlings to new locations. This is a major reason why many countries now have a policy of producing pest- and pathogen-free seedlings so that undesirable biological agents are not dispersed along with the seedling.

The major categories of biological agents which might damage seedlings in nurseries are the following:

- Insects,
- Pathogens: These are microscopic organisms that include fungi, bacteria, viruses and nematodes, and
- Animals: These include mice, rats and squirrels.

There might also be damage from birds, snails and slugs but these appear to be of very minor importance. Large domestic and farm animals can, of course, devastate a nursery but adequate fencing should exclude them.

### 7.2.1 Insects

There are many insects that are potential pests in nurseries, but relatively few appear to be of economic importance to seedling production. In the majority of nurseries insects are a nuisance but they do not regularly cause major plant losses. The nursery foreman should, however, be constantly vigilant to detect any pest/disease problem at an early stage so that preparations can be made for control if this should become necessary. There are several insects, which may at times become a significant problem in some nurseries, and these are considered below.

**Grasshoppers and crickets**

These insects are common in low numbers in many nurseries and do cause some damage by chewing leaves and shoots, especially of tender young seedlings. Grasshoppers vary in size from 1 cm to over 8 cm and the damage they cause individually varies accordingly. The presence of grasshoppers is encouraged by other vegetation which provides shelter and food.

The presence of dead vegetation, especially branches and long grass, can also provide a suitable habitat for grasshoppers. The dense grass shades typical in nurseries also encourage grasshopper attack on the seedlings being shaded. Simple measures to limit grasshopper damage should, therefore, include keeping the area around pot beds clean and minimizing shading of seedlings. If insect numbers and damage are high, it may be necessary to spray with an insecticide such as Fenitrothion.

Crickets can be a nuisance in some instances. These insects tend to hide between and below the tubes during the day and come out to feed at night. If insecticide needs to be used for severe infestations, Fenitrothion applied late in the afternoon should be effective.

**Cutworms and other caterpillars**

Cutworms are the larvae of a moth *(Agrotis)* which lays its eggs on the stem or soil surface and when the small caterpillars (larvae) hatch from the eggs they initially feed and live on the leaves, which may become skeletonized. As the caterpillars become older they spend the day in the soil and only emerge at night to feed. They then frequently cut the stem of small seedlings slightly above soil level, thus giving them their name "*cutworm*". These insects are frequent in many nurseries and show a distinct preference for eucalyptus. The larvae can be found by careful examination of the soil beneath

seedlings which have been cut. The larvae are hairless, grey or brown, 1-2 cm long, and curl up immediately when touched.

If control is required this can be done with an insecticide such as Dursban or Trichlorophon when the larvae are still small and have not reached the stage of entering the soil during the day. After the larvae grow larger and enter the soil they are less easily controlled by a contact insecticide and, therefore, a systemic insecticide such as Rogor should be used. All caterpillars are the larvae of various moths and butterflies, and many of these different species of caterpillar may occasionally cause damage in nurseries. Control can be achieved by picking the caterpillars off by hand, but if the infestation is severe, spraying with a contact insecticide such as Fenitrothion may be required.

**Termites and ants**

Both these insects form colonies with a single queen and numerous workers. Termites (also known as white ants) can cause severe damage to saplings and larger trees by attacking the woody roots. They may be present in nurseries but do not appear to attack seedlings, probably because the roots of seedlings are not sufficiently woody to provide suitable food for them. If grass is used to cover germinating seed, termites sometimes consume part of the grass and build tunnels into the grass covering. This can result in disturbance of seed, which will be reflected in poorer germination. In some instances the termites build such extensive tunnels within pots that subsequent soil collapse follows, exposing roots of seedlings.

Ants are not usually a problem, but instances have occurred where they collect small seeds after sowing. Such ants are known as harvester ants. Ants may also increase the spread of insects such as scales and mealy bugs to adjacent seedlings within the nursery. The most efficient way to control termites and ants is to locate the nest of the colony and destroy it, including the queen. Insecticide such as Dursban can be applied to the soil forming the base of pot beds if it is not possible to locate the colony and destroy it. A termiticide called Marshall SusCon is very effective and has relatively low toxicity to humans.

Pesticides such as DDT, Dieldrin, Chlordane and Aldrin (known collectively as chlorinated hydrocarbon compounds) are very effective against termites but they are also very toxic to humans and animals and they are very persistent in the environment. Their use is, therefore, not recommended. Relatively high concentrations of pesticide can be used when spraying soil because there is no problem with phytotoxicity if the spraying is done before tubes are placed in the pot beds.

### 7.2.2 Pathogens

Pathogens include microscopic organisms such as fungi, bacteria, viruses, nematodes and mycoplasmas. These organisms are too small to be seen with the naked eye and must be viewed with a microscope if they are to be studied and identified. In forest nurseries worldwide by far the most important group of pathogens are the fungi. Fungi comprise many different genera and there are thousands of different species that can cause disease of plants. Fungi are plants that lack chlorophyll so they must obtain their food from dead organic matter (saprophytes) or living plants (pathogens). Most fungi are composed of fine threads (hyphae) that grow within soil and also within and over the surface of plants in the case of pathogens. Fungi reproduce by means of tiny spores which can be disseminated with air, water, seed, compost or soil depending on the species of fungus involved.

For a disease to develop in plants three basic requirements must be fulfilled:

1) The plant must be susceptible to infection;
2) A pathogen must be present; and
3) The environment must be favourable for infection and colonization of the host plant by the pathogen.

Disease only develops if all three of these conditions are fulfilled. If even one of the conditions is unfulfilled there will be no disease. In practice it is usual to find that the above prerequisites for disease are partially fulfilled, leading to varying degrees of disease severity. For example, a plant might be slightly susceptible, the population of pathogens is low, and the environment is only

marginally conducive to infection; this would result in such a low level of disease that it might not even be noticed in a nursery. By contrast, a highly susceptible host plant, high pathogen population and favourable environment for infection could result in epidemic losses. In practice, all gradations between negligible and severe disease are likely to occur at different times in different species and locations.

In general, fungal diseases are favoured by moist and warm conditions such as are typical in high-rainfall tropical areas. This applies especially to diseases of leaves and stems. It is usual to have relatively little plant disease in dry climates for most of the year. In the artificial environment of a nursery there is a high density of genetically similar, closely spaced plants, and watering and shading can create an environment which is relatively favourable for disease. Also, in a nursery that has existed for some years, there is likely to be a build-up of pathogen populations with time so that disease problems also increase.

Disease can occur in any part of a plant, including germinating seed, roots, leaves, stems, flowers and fruit. One system of disease classification is based on the plant organs affected and the type of symptoms that are evident. Thus, we have diseases such as "root rot" or "leaf spot", each of which can be caused by numerous different pathogens. Another system of disease classification is based on the identity of the pathogen; this requires expert knowledge and laboratory facilities.

**Damping-off**

Damping-off is the single most important disease in nurseries. Foremen should become familiar with the symptoms of damping-off and its control. Currently, it is usual for foremen to blame "frost" or poor-quality seed for problems, which are in fact due to fungi. Damping-off is a disease of germinating seed and young seedlings, and is normally most prevalent during the first two or three weeks after germination. It is usual to distinguish two types of damping-off disease:

**Pre-emergence damping-off:**In this disease the seed either rots before it germinates or the pathogen kills the root and shoot (hypocotyl) once it has emerged from the seed but before it has broken through the soil surface. This disease often goes undetected and it is very easy to be misled and wrongly conclude that the seed is not viable. Pre-emergence damping-off can be especially common if seed is sown too deep in cold, wet soil that is poorly aerated.

**Post-emergence damping-off:** Post-emergence damping-off is characterized by infection and rotting of the stem of young seedlings close to ground level. Typically there is discoloration and reduction in the diameter of the stem at the infection site, which is best observed by gently removing the seedlings root from the soil by carefully washing with water. The discoloration (usually brownish and contrasting with the white colour of healthy stems) and diameter shrinkage are due to cell death following invasion by fungal hyphae. This type of infection often causes the small seedlings to fall over because there is little strength left in the rotted stem section, insufficient even to support a tiny shoot that may only have two cotyledons.

Damping-off can affect most species of plant, but small-seeded species, which initially have very delicate stems, are most likely to become affected. *Eucalyptus* and *Cupressus* are often severely affected. Moderate and severe losses occur in nurseries as a result of damping-off. Damping-off can be caused by any of over 30 different fungi, but the three genera *Rhizoctonia*, *Pythium* and *Phytophthora* are of particular importance. The most likely source of the damping-off fungi is the soil that is used to prepare the germination mix. However, they can also originate from the irrigation water, compost, seed, dust, soil splash, and some are able to cause infection from airborne spores.

In highland nurseries there is also frequent damping-off caused by a fungus known as grey mould *[Botrytis cineria).* If this pathogen is causing the problem, the infection point on the stem is often slightly above ground level and results in moist lesions (infected areas of plant tissue) which quickly develop a mass of grayish spores. These spores are easily dispersed in even the slightest air currents and this can very rapidly lead to widespread infection of other seedlings.

A feature of damping-off disease is that it tends to occur in spreading patches. This is because from an initial infection the fungal hyphae are able to spread out and infect adjacent seedlings without having to first produce spores. The rate of spread of such patches can be very rapid so that in a few days extensive mortality can occur in seed trays and seedbeds. If seed is sown directly in tubes, this tends to restrict most damping-off from spreading beyond individual tubes and this is a distinct advantage of direct sowing. There is, however, an exception to this limited spreading between tubes if the damping-off is caused by *Botrytis* (and to a lesser extent by *Fusarium* and other fungi with airborne or splash-dispersed spores). This is because *Botrytis* rapidly produces large numbers of airborne spores which can easily pass over the polythene tubing, which is an effective barrier to hyphal growth.

In the simplest terms, damping-off is a disease that is particularly likely in wet, humid, shaded environments. In general, the following cultural and environmental factors tend to increase the severity of damping-off:

- *Sowing seed too deeply:*- Sowing depth should be no more than 2-3 times the diameter of the seed;
- *Sowing seed too densely*:- This tends to create crowded growing conditions, which favour the creation of a humid microclimate around seedlings, which in turn favours infection;
- *Direct contact and hyphal growth:*- Also, crowded seedlings make it easy for the pathogen to spread rapidly to adjacent plants by direct contact and hyphal growth;
- *Poor sterilization*:- Using a germination mix that has not been sterilized or pasteurized;
- *Poor soil mix:*- A germination mix that is of heavy texture (i.e. containing too much clay and silt and not enough sand) which results in poor aeration and slow drainage of excess water;
- *Excessive watering resulting in prolonged wetness*:- The potting mix should always be moist, but not excessively wet, during germination;
- *Poor ventilation around seedlings*:- resulting in high air humidity and continued wetness of the soil surface and root collar;
- *Excessive shading*: - tends to maintain wet conditions and high humidity. Lack of sunshine also makes the plant physiologically weak and so more susceptible to infection. Lack of light also lengthens the period in which seedlings are in the soft, succulent, growth stage during which they are most susceptible to damping-off;
- *Alkaline soil* (pH over 7);
- *High nitrogen content in germination mix*; *Manure that is not well decomposed*; and *too much compost in the germination mix*;
- *Too many weeds*:- help to maintain a humid microclimate; and
- *High salinity* in the germination mix or irrigation water.

***Control of damping-off:*** The above conditions favouring development of damping-off should be minimized in every nursery. The specific changes that can economically be made will depend on the circumstances prevailing at each nursery. A major improvement in control of damping-off is usual if it is possible to sterilize or pasteurize soil. The use of solarisation to heat soil is relatively simple and is recommended especially if seed trays are used for germination. Care must be taken to prevent re-infestation of treated soil with pathogens, which can easily occur if strict hygiene is not practiced.

In most nurseries it should be relatively easy to ensure that the following simple measures are taken to minimize damping-off:

- Use well-drained germination mix of light texture (i.e. with a high proportion of sand);
- Sowing density should give a spacing of 1-2 cm between seedlings;
- Watering frequency should be carefully controlled to avoid excess wetness; and
- Shading should be reduced as soon as possible.

The following practices can further help to reduce damping-off disease:

- After sowing seeds, cover them with fine sand. Sand contains few pathogens and helps to maintain good drainage and aeration. It also enables rapid emergence of the hypocotyls (shoot), and thereby reduces the time available for development of pre-emergent damping-off;

- If watering is done late in the afternoon, high air humidity and a wet soil surface might prevail throughout the night and favour damping-off. Watering should be done in the mornings and early enough in the afternoon to allow drainage and evaporation of excess water before the onset of evening;
- The seed-bed germination mix should be replaced periodically to prevent build-up of pathogen populations in successive years. Careful observation of the incidence of damping-off in the previous year will indicate when replacement is required; and
- During pricking-out, seedlings should be held by a leaf and not the stem. The stem is very delicate and if slightly damaged through touching with the fingers is more liable to infection from damping-off fungi.

If adequate control of damping-off is not achieved by implementing cultural methods as suggested above, it might be necessary to use chemical fungicides. Fungicides are expensive and need to be used with care to prevent health hazards to workers. It is, therefore, not recommended to rely on fungicides for control of damping-off but rather to concentrate on improving cultural methods. Damping-off can develop very quickly and high losses can occur within a few days. As a last resort, spraying with a fungicide should help to slow down the development of damping-off. However, once disease is well established in a favourable environment, even repeated spraying may not effectively control it. The most suitable fungicide to use depends on knowing the species of fungus involved. Fungicides such as Captan, Dexon, PCNB, Dithane M-45, or Benlate could be used on a trial basis to see if they control the disease. With time, each nursery should accumulate information about which fungicides are effective in its specific circumstances. If experience from previous years indicates persistent damping-off, treating the seed with fungicide before sowing should be considered. A suitable fungicide for seed dressing is Thiram.

It is also possible to apply a fungicide drench to the soil before sowing. Prophylactic spraying with fungicides before damping-off develops is possible but should only be considered for valuable seed or where all other attempts at control have failed.

### 7.2.3 Higher animals

Besides straying domestic stock such as goats, sheep, donkeys and cattle, which may enter nurseries if fencing used is inadequate. Rats, mice and squirrels are a problem in some nurseries. Rats, mice and squirrels (all rodents) might eat stored seed if it is not placed in vermin-proof containers such as metal tins. Seed stored in plastic bags or plastic jars can be eaten because the rodents have sharp teeth that allow them to gnaw through soft materials. Alternatively, the store itself can be made rodent proof.

Those nurseries which provide a suitable habitat for rodents close to seedling beds are most likely to suffer significant damage. Such habitats include, particularly, stone walls close to seedbeds and pot beds, as well as long grass and heaps of rubbish. Reductions in rodent populations can be achieved by keeping grass short, removing rubbish to heaps some distance from the seedling areas (and composting all organic materials), and not building stone walls close to seedling-production areas. Food scraps should not be left lying around to discourage rodents.

More direct control methods can include the setting of traps and laying of poison baits such as coumarine or warfarin. The baits must be sheltered to protect them from rain. Rodent poisons are toxic to humans as well as domestic animals, so precautions are required to limit access only to rodents. A cat can be useful to help in control of rats and mice. A covering of wire mesh supported on a suitable frame should prevent rodent damage, but this is an expensive solution and would only be feasible for protecting small numbers of valuable seedlings. Birds are not usually important in damaging seed or seedlings. Indeed, birds are frequently seen feeding on insects on seedling foliage and, therefore, they have a beneficial effect and should be encouraged.

# MODULE 8: SEEDLING TRANSPORTATION AND HANDLING

## 8.1 Grading, packing and transportation

### 8.1.1 Grading

In any nursery there are always some poor-quality seedlings which would have a low chance of survival if planted out. Such seedlings should not be planted at all as this is a waste of money and will incur the further cost of replacement planting (beating-up). The process of separating poor-quality seedlings from those of reasonable and high quality is known as "grading" or "culling". It is usual to expect 10-20% of the seedlings produced to fall short of minimum quality standards and these should be culled. The reasons for poor quality include both genetic and nursery-management factors.

In many nurseries there is often very little culling, and in many instances virtually all living seedlings are dispatched for planting. This is a major reason for the frequent poor survival in plantations. The solution is to plan excess production sufficient to allow for a culling of 20% of seedlings. If pits have been dug, there is a strong temptation to plant them even if only inferior seedlings are available.

The best-quality seedlings should be used on the most difficult sites, areas with difficult access, and areas which are of particular importance. Seedlings of slightly poorer quality can be planted on more favourable or less important sites. If supplementary watering after planting is possible (e.g. private plantings around homes, schools, churches), then you may still use lower-quality seedlings and obtain good survival.

In order to be practicable, the culling must be based on shoot characteristics that can be very rapidly assessed by the relatively untrained labour force working in nurseries. From experience in many countries, seedling height, collar diameter and general appearance of seedlings have been found useful criteria on which to base culling.

**Seedling height**

The seedling should be about twice the height of the tube. The tubes in the majority of nurseries are 15-cm long, so the seedlings should be about 30-cm tall. Excessively tall (over 40 cm) and short (less than 15 cm) seedlings should be culled.

**Collar diameter**

The collar diameter (stem diameter at soil level) should be as large as possible; and the thin, etiolated plants should be discarded. The collar diameter should be at least 2 mm, and with good nursery management it should be possible to adopt 3 mm as the minimum acceptable standard.

**General appearance**

Seedlings should have a balanced and symmetrical growth of normal healthy green leaves without yellowing or other discoloration. There should be no evidence of insect pests, disease, or obvious mechanical damage.

**Single seedling per tube**

At an early stage in growth seedlings should have been reduced to one per tube. If, for whatever reason, this has not been done, then such tubes should be thinned to one seedling at this stage. This, of course, assumes that the tube contains one seedling which meets the above three culling criteria.

## 8.2 Packing and transporting seedlings for planting out

Preparing seedlings for planting requires packing, which if not done carefully can result in appreciable deterioration of seedling quality, with consequent reduction in survival. The other principal reasons for poor survival rate are that seedlings are mishandled during transport, loading and unloading operations. One must not expect a high survival rate from seedlings that are broken or damaged mechanically. In many places seedlings have been treated like any other commodity especially while being transported and unloaded by dump trucks. Maximum care must be taken for the seedlings when they are transported from nursery to planting sites. The best quality seedlings could be damaged if they are handled carelessly.

On the other hand it is also common to transport seedlings on donkey back or carried by people. Since people cannot afford carrying many seedlings with pots; because of the weight of the soil, they remove the plastic pots with the soil in order to carry as many seedlings as they can. This can tremendously affect the survival rate of seedlings. Therefore, proper care must be taken during transporting the seedlings as safe as possible to the planting site. To achieve acceptable results the following should be done:

- Only send those seedlings to the field which have passed the grading standards; and
- Water the seedlings thoroughly the day before lifting the tubes.

Ensure that the whole depth of the tube has been moistened by lifting random seedlings and examining them to ensure that the wetting front has passed all the way to the bottom of the tube. This usually requires repeated watering with a little time difference between each to allow infiltration. For instance, for dry 20-cm long tubes it will require 3-4 successive watering to wet the whole tube. Moisture stored within the tube is a major reason why tubed seedlings have an advantage over open-rooted seedlings and this advantage is largely lost if tubes are not thoroughly watered before dispatch.

This moisture reserve will help the seedling to better tolerate dry periods if there should be several days without rain following planting. The following critical issues must be considered during lifting and transport:

- When lifting seedlings they should always be handled by holding the tube and not by pulling on the stem as this can easily damage the shoot, and also lead to subsequent pathogenic infections.
- Transport seedlings in a vertical position by placing them closely stacked in boxes. This minimizes shoot damage and soil loss from both the bottom and top of open-ended tubes.
- Placing trays full of seedlings horizontally into trucks can result in significant soil loss from tubes, often exposing roots to air drying, as well as mechanical damage to shoots. Metal platforms on vehicles can become very hot and kill roots that come into contact with them. Pouring water over the platform or spreading a layer of straw, grass, soil or similar material on it helps to reduce this problem.
- If there are sufficient numbers of boxes, they are loaded onto trucks with minimal further loss of soil during transportation and unloading. To increase the carrying capacity of trucks, shelving is required so that several layers of boxes can be accommodated, one above the other, and so make transportation more economical.
- The seedlings should be covered so that they are not exposed to sun and wind during the trip from nursery to plantation. There should be some space between the seedlings and the cover to minimize mechanical damage. Covering is especially important if the distance from nursery to plantation is appreciable as desiccation of seedlings depends largely on the length of time they are exposed. If covers are not available, the effects of desiccation can be reduced by transporting on rainy or cloudy days.
- Potted plants can be transported safe if they are stacked on the floor of trucks or other vehicles in an upright position. This consumes a lot of space and requires quite frequent travel to and from the planting site. Instead, the seedlings can be laid one on top of the other, the shoots of two rows facing each other. In this manner the seedlings can be transported when the distance is reasonably short but should be unloaded and stacked in an upright position and the planting needs to start soon.
- Bare-rooted seedlings can be laid down on wet banana or false banana (enset) leaves, sacks or other materials with the roots puddle with soil and water. The bundles of seedlings can be stacked upright on the vehicle floor. In this way, quite a large number of seedlings can be transported at a time. Where the planting site is far away and vehicles are not available, the bundles can be transported by donkeys, horses or mules.
- Normally, plants arrive one day ahead of planting. Where shade and watering facilities are available, planting stock can be brought in several days before planting is to take place. As

soon as the plants arrive at the planting site, they must be watered and stored in cool, moist and shaded place until they are planted.

- Only dispatch the number of seedlings from the nursery that can be planted in one day.
- The seedlings should be planted as soon as possible, preferably within hours of arriving at the plantation site. After carefully unloading the seedlings, they should be placed in a shaded, sheltered, position which is the coolest available. If there is any delay in planting, it is essential that the moisture content of tubes be constantly monitored, and if they become dry supplementary watering is carried out. If seedlings are planted with low tube-moisture content this will have a detrimental effect on survival if good rains do not immediately follow planting. It is common in Ethiopia to observe several days of dry weather after planting. Thus, it is essential that each seedling has adequate water stored in the potting mix at planting time.

The general lack of boxes is a significant problem for efficient transport of seedlings. Firstly, it necessitates repeated handling of seedlings, which is not only labour intensive but increases the probability of additional soil loss from tubes with each handling. To reduce this soil loss from tubes, nursery managers tend to transport seedlings that are not adequately watered because relatively dry soil is less likely to be lost from tubes. Thus the lack of boxes is indirectly responsible not only for loss of soil but also for planting seedlings with a relatively dry potting mix. The situation can only be improved if money is made available for purchase of sufficient numbers of suitable boxes.

# MODULE 9: SUPPORTING NURSERIES TO PRODUCE PLANNED TARGETS

The type of support needed for all type of nurseries is in be related production, technology, inputs, credit, infrastructure and marketing. The support can be classified under soft and hard. Soft supports are relates to information, training and advice while hard support on the other hand relates to inputs such as tree seed, wate, tools and fencing.

## 9.1 Supporting central nurseries to produce planned targets

### 9.1.1 Training

A good nursery operation relies on continuity of staffs that are professional, careful and honest. Although the casuals or technical workers do most of the work described here, everyone in the nursery ought to have as much knowledge about nursery management and operations. Understanding even in a simplified way the processes in a germinating seed, a rooting cutting or a growing seedling, and the importance of high humidity, watering, shading, etc. will help prevent many errors in daily work. Only when all workers feel that they are part of the nursery operation, when they understand the part they play and when they feel proud of it, can work efficiently and productively.

Staff training can take the form of scheduled courses or of regular (weekly, monthly) staff meetings covering a particular topic. This can be reinforced by repeating explanations of techniques during work.

### 9.1.2 Introduction of new technologies

A mixture of new, adopted and indigenous technologies should be employed in central nurseries. Central nurseries should have regular and easy access to new and appropriate technologies. Experts and Advisors at Federal, Regional and Zonal level should play a leading role in introducing new technologies to central nurseries.

## 9.2. Backing self-help group nurseries in production and marketing

There is ample experience from SLM in which self-help group nurseries are successfully producing and delivering quality seedlings to a project. It only requires good training, provision of essential equipment and supervision of the production system.

This arrangement has benefits of enabling the woredas to adequately provide planting materials. Besides, farmers will develop skills and knowledge about managing seedlings and generate income.

### 9.2.1 Training

Training should be provided to group members focusing on technical skills required of nursery work as well as basic business and management skills. Farmer -to farmer training and exchange visit is a powerful tool to create awareness and enhance capacity.

### 9.2.2 Equipment and nursery space

Kebele administration is expected to offer a nursery space to self-help groups (minimum 0.5 ha). The land should have access to perennial water supply. Besides, the following material support should be provided by the woreda office of agriculture to user groups engaged on multiplication of planting materials: wheel barrow, watering can, spade, rake, root pruning scissors, seedling tray, pickaxe, and sand sieve, Polythene tube, watering canes, bucket and rakes. Table 12 below shows, the list of equipment's required for establishing a group nursery with production capacity of 50,000 seedlings.

**Table 11: Minimum equipment requirement for a group- based nursery with production capacity of 50,000 seedlings**

| S/N | Type of hand tools and equipment | Unit | Quantity | Unit price | Total cost |
|---|---|---|---|---|---|
| **A** | **Hand tools and equipment** | | | | |
| 1 | Wheel barrow | No | 2 | 500 | 1,000 |
| 2 | Watering can | No | 3 | 100 | 300 |
| 4 | Spade | No | 5 | 90 | 450 |
| 5 | Rake | No | 3 | 100 | 300 |
| 8 | Root pruning scissors | No | 2 | 100 | 200 |
| 14 | Seedling try | No | 5 | 100 | 500 |
| 15 | Pickaxe | No | 2 | 90 | 180 |
| 18 | Sand sieve | M | 2 | 25 | 50 |
| 19 | Meter (50m) | No | 1 | 150 | 150 |
| | **Subtotal** | | | | **3,130** |
| **B** | **Polythene tube** | **Kg** | **50** | **50** | **2,500** |
| **C** | **Seed** | **Kg** | **10** | **100** | **1,000** |
| **F** | **Seedling purchase cost** | **No** | **50,000** | **0.5** | **25,000** |
| | **Total** | | | | **31,630** |

### 9.2.3 Provision of initial stocks of grasses and seeds

At the time of establishment, the woreda office of agriculture in collaboration with SLM coordination, should facilitate the support on the provision of different species of seed (up to 6 kg) and different species of initial grass stocks (500-1000 clumps). Once group nurseries are established, they will be responsible for fulfilling their seed and grass stock demand.

### *9.2.4* Bylaw development and legalization

Regional and Zonal experts/Advisors and Woreda TC members are expected to assist self-help groups to develop bylaw and get registered as Small and Medium scale enterprise. Although small and medium enterprises are not promoted in SLMP, the establishment of group nurseries is suitable for this type of organization. Small enterprises have a capital of 50,000 – 500,000 ETB and between 6 to 30 workers. Due to Cooperatives Promotion Agency's:

- long processing of the legalization
- Weak follow-up and professional backstopping due to excessive workload,
- Very limited practice-oriented training and focusing on theory
- Cumbersome and tedious bye-law document and use of so many ledgers at a time in which the documentation is also poor

In contrary, medium and small enterprises Promotion Agency more preferred due to:

- Fast processing of the legalization and immediate certification
- Relatively better follow-up
- More of practice-oriented than focusing on theories
- Use of customized, short and easily understandable bye-law formulation
- Focusing on a number of small groups that will be amalgamated in the future than aiming on one or two non-manageable groups.

Hence, the use of this mandated and more effective agency would seem more preferable.

### 9.2.5. Agreements between Woreda and self-help group nurseries

The purchase of planting materials from self-help groups is one option of fulfilling demand. Efforts should be made to encourage user groups to produce planting materials for the market in large quantities. Woreda office of agriculture can make contracts with user groups who have space and capacity for multiplication of various planting materials. The contract fixes the types of plant material to be provided, time of delivery, delivery place and the guaranteed price for specified quality standards.

A model agreement currently being used in SLM- Oromia is attached (Annex 7). The following essential elements are include in the agreement:

- The agreement is renewed per every planting season,
- The agreement has legal binding articles that would enable to plant standardized seedlings in time,
- Woreda-level professionals are obliged to give intensive support to producers for quality production,
- At start-up 20% of the total amount, upon finishing 50% of the work 30%, and finally, upon completion and delivery of the product the remaining 50% would be paid.

## 9.3 Backing individual nurseries in production and marketing

Individual nurseries largely depend on family resources. However, Government/projects may provide technical and material assistance to operators, particularly during nursery establishment. This assistance usually focuses on providing good quality seed, training on basics of seedling production and nursery management and assistance on equipment's such as water cans, hoes, spades and rakes. Commercial-oriented individual nurseries evolve as self-funded through seedling sales and the provision of technical services. Closely follow up and supervision is also provided.

### 9.3.1 Training

A training programme may not be designed separately for private nursery owners; we mostly include them in the list of trainees at the time we program for any other training. Leading farmers who established their own private nurseries are usually invited in the regular Training and Visit Program (Farmer-to-farmer Experience Exchange Visit).

Training support for private nursery owners should focus on technical aspects and entrepreneurial skill, namely: seed collection, seed purchase, germination, and seedling husbandry. Besides, it is necessary to equip them with entrepreneurial skill (Business planning, bookkeeping, contract negotiation, development of business plan, market assessment and etc.).

### 9.3.2 Equipment

Water can, hoes, spades and rakes would be bestowed on the basis of leading farmers' surpassed performance. It is advisable to give them on farmers' days. Or, in case, if scarcity of such hand tools prevails, they must be kept in FTCs to use them turn by turn.

### 9.3.3 Provision of initial stocks of grasses and seeds

The office of agriculture of the woreda in collaboration with SLMP, should provide initial stocks of grasses (up to 50 clumps) and starter seeds of different species (1-2 kg), and distribute them to contracting farmers. If the species to be produced are indigenous ones, it could be up to the individual farmer or the group to collect healthy seeds in their vicinity. The quality of the seeds collected can be checked by woreda experts.

### 9.3.4 Agreements between Woreda and individual nurseries

As done for Self-help group, a contractual agreement can also be entered with private producers which can be handled in the following ways:

- Contract agreement where payments are paid by phase by phase (when site clearance and sowing of seeds is completed, the second payment where seedlings have well germinated, and finally when the agreed number of quality seedlings is delivered)
- The second arrangement can be done where payments are effected when agreed number of quality seedlings is delivered

# MODULE 10: HOW TO MANAGE A NURSERY

After a nursery is established, there are many management considerations relevant to the effective and economical production of quality seedlings Nursery management can be viewed as the day-today activities which are performed within an annual time frame to produce maximal numbers of quality seedlings in the most economical manner. To effectively manage a nursery, the nursery manager must have a clear idea of on the most important elements of nursery management. These are mainly, planning of activities, record keeping, regular inventories and quality control.

## 10.1 Planning activities

Careful planning, organization, implementation and control are required to avoid mismanagement with resulting poor quality of planting stock. In order to simplify activities, a plan of activities, covering at least one productive season in the nursery should be made. This will help to plan and implement activities that require more labour or special equipment. Some labour intensive activities like sowing, transplanting, root-pruning and lifting must be done in a limited time, and these periods are usually of critical importance. Other labour intensive activities like pot filling, weeding and shading must be carried out more or less continuously during the production season. These continuous seven-days-a-week activities should be well supervised as they are essential if quality target seedlings are to be produced.

Nursery management can be simplified if a detailed plan is prepared before the start of the nursery season. The nursery management plan includes all important nursery activities. It should cover one full cycle of the nursery year, starting with an empty nursery at the end of the main rains and extending until the next rains when the seedlings are transported to the planting site.

Following the nursery management plan it is possible to smoothly implement those nursery activities that require most labour or special equipment. Certain labour - work such as transplanting and lifting must be done during a limited period of time, and these phases are usually critical; success of the whole planting year depends upon them. Another type of labour-intensive activities is the phase during which pots are filled. This activity can be done over a longer period, and should be planned to start well in advance to avoid bottlenecks (the soil coming late, a shortage in the plastic tube supply, etc).

Some activities, like the watering of the seedbeds, must be done continuously, regularly and over a certain period of time. For such work, the management plan must reserve a reliable team of permanent or semi-permanent nursery workers who can be employed seven days a week for the period in question. The annual nursery management plan is based on the following factors: number and type of seedlings to be raised, applicable work norms andtiming of activities.

The number and type of seedlings to be raised is decided when the nursery was set up. However, the annual amount of seedlings, species by species, is decided every year. *Juniperus procera*, for example – needs a full year in the nursery before reaching transplanting stage. Nursery work norms, together with the seedling production level, help to establish the need for casual labour. The applicable work standards are based on experience from the nursery itself, or from similar nurseries elsewhere in the country.

In calculating the need for casual labour a provision must be made for weekends as well as for official and church holidays. The people who live in the Ethiopian highland can be counted to work only for 20 to 25 days per month. Therefore, an average need for 600 man-days for sowing would translate into a requirement of 30 people for a sowing period of one month (20 working days).

## 10.2 Recording in nursery operations

Records are important elements in nursery operations. They are critical especially for newly appointed staff member who likes to learn about the local nursery management and practices. In contrast, inadequate record keeping can result in loss of valuable information, information which could improve methods of production. Nursery records can be conveniently divided into three categories as: seedling production, costs, and daily diary.

In the interest of standardization, and to ensure that all relevant information is recorded, nursery registers should be produced and used by anyone running or starting a nursery. The register provides an adequate annual record of production procedures and, with time, a history of each particular bed. This means that each bed in the nursery, whether it is a seedbed or a pot bed, must be allocated a particular number which it retains permanently thereafter. There should be a label indicating the unique number of each and every seedbed and pot bed in the nursery.

The nursery register is divided into five major sections: Seed source, Sowing, Pricking-out (or transplanting), General remarks, and Dispatch location.

**Seed source**
This section deals with details of seed-collection and should include a unique batch number which is applicable to only one specific collection. From this batch number alone it should always be possible to retrieve the other collection details. If local seed collections are made, then a local seed register should also be started, and particulars of each collection recorded. If seed is received from external sources, it should already have its own unique batch number. However, if for some reason it does not, it should immediately be given a number from the local register, and all relevant collection details recorded.

**Sowing**
This section deals with recording basic information about sowing and should include dates, rates, pre-sowing treatment, date germination started, date germination was completed, actual germination rate (percent) and actual number of germinant. This section provides valuable information of particular use in organizing future sowings, and is well worth the little extra effort required to acquire it. The total labour expended on sowing should be recorded in man-days.

**Pricking-out**
This section is to record the essential details of pricking-out, including dates when the work was done, the seedbed number of the transplanted seedlings, size of pots used, and potting mix used. The survival rate of the seedlings should be recorded when no further mortality is likely to occur. The total labour expended on pricking-out should be recorded in man-days.

**General remarks**
This section is included to encourage nursery foremen to closely monitor the quality of the plants they are growing. The specific dates of root-pruning(s) should be recorded here without fail. Notes on watering, shading, pests and diseases, weeding, fertilizers, etc., should also be included here.

**Dispatch**
This section provides information about when, and how many seedlings are sent to be planted in various locations. It is very important to enable a specific plantation to be traced right back to the nursery and seed collection from which it originated. This facility is an essential prerequisite for effective forest management.

The data recorded in this section of the nursery register allow for examination of nursery- and seed-origin factors which may have contributed to poor survival or growth after planting. Alternatively, Section 5 may also hold the key reasons as to why a plantation in a certain site was particularly successful.

Such success may in fact be traceable to either good-quality nursery stock or seed of superior genetic quality. A sufficiently detailed Section 5 might be the only available way to identify that desirable superior genetic source or nursery. After it is identified, this of course creates the opportunity to disseminate more widely the methods of the identified superior nursery or genetic source.

### 10.2.1 Keeping records

Good record keeping in the nursery helps to run the nursery well. References to documented records are important for the current nursery management staff and especially important for any newly appointed staff that can learn about nursery needs and practices by studying the records. Inadequate record keeping, results in the loss of valuable information about new methods, sources of seed, suitable planting times and different problems in the nursery.
The main purpose of recording nursery data, activities and experiences is to make planning and management for the coming years easier. With proper record, upcoming activities can be better planned. Potential bottlenecks that are apt to occur every year can be better met; deadlines and production targets for seedling production can be more easily attained. There are 3 types of technical records that should be kept for the nursery. These are: a daily journal, registers, and inventories.

In addition to these, a financial record is compulsory. All relevant information in line with daily operations should be recorded in a journal. The time of sowing of the different species in individual compartments should be indicated, as well as the time of transplanting and any other treatments given to the seedlings. The time and the labour used for different nursery operations should also be recorded daily. Notes about nursery efficiency, the final number of seedlings produced per square meter, etc., are useful. A record of water consumption and irrigation practices should also be made. All this information is essential for a continued successful nursery operation, and together with financial records, gives the basic data for calculating seedling production costs.

Labels are important for nursery records, to avoiding mix-ups with species, provenance's, sowing dates and other data. The labels should be used from the moment the seeds have been collected until the seedlings are released to the field. Labels should, at the least, show the seed batch number and the botanical name of the seedlings. All countries in the world use Latin botanical names for trees. The use of a Latin name is safe vis-a-vis use of a local name, which likely creates confusion.

## 10.3 Regular inventories

A thorough nursery inventory should be taken annually to record the seed stock, consumable materials like plastic tube and fertilizer, tools and expendable equipment's. The annual inventory is best done between the dispatch of plants from the previous nursery season and the beginning of the new nursery season. Local materials like watering cans and hoses, wheel barrows, etc., can be procured before the high nursery season. Purchase orders for imported materials such as plastic tube should also be prepared at this time since the arrival of such items normally takes up to one year from the date of ordering.

Seedling production is monitored with monthly inventories. The nursery manager must know at every moment how many healthy seedlings he has in his nursery to compare against the annual production target and against the safety margin of seedlings needed to reach this target. It is a normal biological fact that some seedlings will die before the planting season and another amount may be too weak for transporting.

The greatest problem occurs with a sudden dieback of seedlings. If the dieback is not recorded in time, the achievement of the annual production target may be at risk. By taking regular seedling inventories, the problem of sudden diebacks can be overcome. If the number of losses is closely monitored and those pots removed from beds, there remains a possibility to produce additional, fast-growing seedlings for the coming planting season. Fast growing and simple to raise *Sesbania bispinosa* seedlings can be substituted for dead acacias or eucalyptus. If the latter half of the nursery season is already at hand, it may be feasible, in case of sudden losses of seedlings, to make enquires at neighbouring nurseries where it might be possible to obtain the missing seedlings.

The first seedling inventory is done immediately after sowing by counting and measuring the number of beds, the dimensions of the beds (length x width), andthe number of pots per square meter

The next inventory should be taken a week or two after the pricking out. A simple way to do this is to take a random sample of 100 pots from every bed. In each sample the number of empty pots and pots with viable seedlings is recorded, and the survival percent calculated;

$$\text{Survival \%} = \frac{100 \times \text{no. of viable seedlings}}{\text{Total number of pots}}$$

Such a survival count should be carried out once a month up to the time of lifting.

## 10.4. Quality control

Besides quantity, the quality of seedlings should be continuously monitored. Empty pots and sick as well as weak seedlings should be recorded and removed from production beds. Seedlings with diseases must be taken away from the nursery or destroyed by burning or burying with notes taken. Weak but healthy seedlings can be grown further for possible use in the beating up.

At the time of lifting, seedlings should meet the following requirements: the root- to-shoot ratio should be in balance, the size should be correct, the seedlings should have no damage and the seedlings should have a healthy colour.

All seedlings that do not fulfil these requirements, even one of them, must be discarded from the transport. The optimum seedling size for planting is between 15 and 40cm, depending on pot size and species. The larger the pot, the bigger the seedling can be at planting. If the seedling happens to be over-sized before the planting, the stem of the seedling has become slender and its ability to endure transport is low. The root-to-shoot ratio is too small, and such seedlings should not be accepted for standard planting.

The use of large seedlings favours survival since these can withstand weed competition better than smaller seedlings. The planting shock, however, is greater for big seedlings, and there will not necessarily be any advantage in their growth pattern after the first growing season. It is evident that height alone does not suffice for grading plants. An additional characteristic is the root collar diameter which correlates highly with seedling survival. The thicker the root collar, the better the survival.

## 10.5 Transporting of seedlings for field planting

### 10.5.1 Organization of the work chain

The organization of seedling transport is the last link in the seedling production chain and recording for the batch. It is the final step between the proper nursery season and the planting season. The success of plantation establishment is greatly dependent on the efficient lifting, loading and unloading of seedlings. The handling and transport of seedlings is the easiest if wooden or plastic crates designed for that purpose are used. Seedling crates are built to standardized dimensions: length 33 cm, width 17cm and height 25 cm. The weight of one create with seedlings should not be more than about 15kg. The crate capacity depends on the pot size.

An adequately trained and equipped labor force must be available in advance at both ends of the transport chain. This is especially important in the field. A truckload of 5,000 to 6,000 plants should be planted out within 2 hours of their offloading. If a tractor and trailer is used for seedling transportations, the transport efficiency is greatly improved if 2 or 3 trailers can alternate with the tractor.

If transport from the main nursery to the planting site exceeds one hour, strategically located temporary nurseries, less than 2 to 3km from the planting sites, should be available to facilitate the chain of transport and planting. Proper attention, however, must be given to the decision to use temporary nurseries since they always involve a risk of losing some seedlings due to double transport and often unavoidable water supply problems.

### 10.5.2 Transport capacity

Seedlings are usually transported from the nursery with trucks and tractors. If the seedling crates are well designed and well-constructed, they can be loaded in piles one on top of the other. In addition, plastic bags can be used for short distances. The method of using crates or plastic bags requires a special device on the truck or tractor platform. Two or more, often 3 loading decks must be constructed above each other. A truck with three loading decks has a platform area of about $24m^2$. The maximum transport capacity of such a truck can be calculated by loading the seedlings without crates or plastic bags, vertically in the three decks. The pot size will determine the number of seedlings per truck load.

A common way of loading seedlings is the so-called “sardine-method”. The seedlings are loaded horizontally on the truck or tractor-trailer deck above each other, like sardines. This method users the deck volume most efficiently, but it is detrimental to the seedlings. The other possibility of transporting seedlings – over short distance – is to use pack animals or porters. Generally, however, manual transport and handling of seedlings should be limited to carrying pots from the beds to the truck and from the truck to the planting site. Normal seedling crates can be used; on steep slopes the seedlings may be carried in back packs.

It is preferable to move seedlings on cloudy or rainy days to prevent desiccation during transport. When moving seedlings to temporary nurseries before the planting season, transport should be done early in the morning or late in the afternoon.

# 11. REFERENCES

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Useful tropical plants (www.tropical.theferns.info)

# 12. ANNEX

*Annex-1. Characteristic tree species*

| No. | Tree species | Number of seeds per kg of pure seed | | | Germination % | Seed treatment | Germination (days) | Sowing time |
|---|---|---|---|---|---|---|---|---|
| | | Minimum | Average | Maximum | | | | |
| 1 | Acacia abysinica | | | | 30-60 | 2 or 5 | 7-15 | 1 |
| 2 | Acacia allbida | 7500 | 9000 | 11000 | 34-90 | 1, 2 or 5 | 5-20 | 2, 3 |
| 3 | Acacia asak | | 5500 | | | 0 | | |
| 4 | Acacia cyanophylla | 20000 | | 67000 | 42-70 | 3 | | |
| 5 | Acacia decurrens | 45000 | | 95000 | 47-70 | 1 | 15-20 | 1, 2, 3 |
| 6 | Acacia etbaica | | | | | 9 | | |
| 7 | Acacia lahal | 3000 | 4000 | 4500 | | 0 or 5 | | 12, 1, 2 |
| 8 | Acacia mearnsii | | 73000 | | 20-50 | 1 or 2 | 9-30 | |
| 9 | Acacia melanoxylon | | 68000 | | 30-60 | | 10-30 | |
| 10 | Acacia raddiana | 4500 | 9000 | 11000 | 60-90 | 1 or 2 | 4-15 | 1, 2 |
| 11 | Acacia saligna | 12000 | 21000 | 31000 | 45-85 | 1 or 2 | 5-15 | 3, 4 |
| 12 | " Acacia Senegal | 14000 | | 80000 | 40-90 | 1 or 5 | | 2, 3 |
| 13 | Acacia Seyal | 8000 | 9500 | 13000 | 30-90 | 1 or 2 | 3-10 | 3, 4 |
| 14 | Acacia Sieberiana | 18000 | 20000 | 22000 | 60-75 | 1, 2 or 5 | 4-10 | 1 |
| 15 | Agave Americana | 3000 | 3250 | 5000 | | 1 or 2 | | 8, 9 |
| 16 | Agave Sisalina | | | | | | | 8, 9 |
| 17 | Albizia gummifera | | 12000 | | 70-80 | 0 or 2 | 3-10 | |
| 18 | Albizia lebbeck | 7000 | | 1200 | 70-90 | 2 | | 1, 2, 3 |
| 19 | Azadirachta indica | 2000 | 5000 | 8000 | 60-80 | 0 | 30-40 | 1 |
| 20 | Balantic Aegyptiaca | 800 | 1000 | 1200 | 60-80 | 2 | 10-30 | 1, 2 |
| 21 | Cajanus Cajan | | | | | 4 | | 12, 1 |
| 22 | Carica Papaya | | | | | 0 or 7 | | 2, 3 |
| 23 | Carrisa edulis | | | | | | | |
| 24 | Cassia Siamea | | 39000 | | | 0 | | |
| 25 | Casuarina Cunninghamiana | | 1500000 | | 70 | 0 | | 9, 10 |
| 26 | Casuarina equistifolica | 400000 | 735000 | 900000 | 50-70 | 0 | 11-30 | 12 |
| 27 | Citrus sinensis | | | | | 0 | | 9, 10, 11 |
| 28 | Coffee Arabica | | 3500 | | | 0 | | |
| 29 | Cordia afticana | 2500 | | 4500 | 46-80 | 0 | 40-60 | 1, 2 |
| 30 | Croton macrostachyus | 16000 | | 27000 | 40 | 0 | 45-60 | 1, 2, 3 |
| 31 | Cupressus lusitanica | 100000 | | 290000 | 30-90 | 0 | 10-30 | 9, 10 |
| 32 | Delonix regia | 1800 | | 2200 | 60-90 | 0 or 5 | | 2, 3 |
| 33 | Dodonea anguistifolia | 90000 | | 100000 | 30-70 | 0 or 5 | | |
| 34 | Entada abyssinica | | | | 70 | 0 | | |
| 35 | Eucalyptus comaldunesis | 100000 | | 2100000 | 60-90 | 0 | 3-13 | 1, 2 |
| 36 | Eucalyptus citriodora | 110000 | | 1200000 | 60-90 | 0 | | 1, 2 |
| 37 | Eucalyptus Globulus | 60000 | | 400000 | 60-90 | 0 | 4-15 | 1, 2 |
| 38 | Eucalyptus saligna | 1700000 | 2000000 | 3000000 | 60-90 | 0 | 3-12 | 2, 3 |
| 39 | Eucalyptus tercticornis | 200000 | 2230000 | 2900000 | 30-70 | 0 | 14-30 | 1, 2 |
| 40 | Grevilla robusta | 70000 | | 110000 | 30-90 | 0 or 8 | 15-25 | 11, 12 |
| 41 | Hagenia abyssinica | | 225000 | | | 0 | 10-25 | |
| 42 | Jacsaranda mimo sifolia | 63000 | | 80000 | 50-85 | 0 or 8 | | 1, 2 |
| 43 | Juniperus procera | 11000 | 45000 | 50000 | 60-70 | 0 | 25-80 | 7, 8, 9 |
| 44 | Leucaena lecocephala | 13000 | 20000 | 34000 | 40-85 | 0, 3 or 5 | 8 | 2, 3 |
| 45 | Mangifera indica | 45 | 50 | 55 | 75 | 0 or 2 | | 8, 9, 10 |
| 46 | Melig Azedarach | 500 | 2100 | 3500 | 85-100 | 0, 8 or 9 | 25-75 | 11, 12, 1, 2 |
| 47 | Morus alba | 325000 | | 700000 | 10-30 | 0 | | |
| 48 | Olea Africana | 2500 | | 3500 | 10-30 | 0, 6, or 8 | | 9, 10, 11 |
| 49 | Oxytenanthera abyssinica | | | | | | | |
| 50 | Parkinsonia acculata | 8000 | 13000 | 15000 | 60-90 | 1, 2, 4 or 5 | 2-10 | 2, 3 |

| No. | Tree species | Number of seeds per kg of pure seed | | | Germination % | Seed treatment | Germination (days) | Sowing time |
|---|---|---|---|---|---|---|---|---|
| | | Minimum | Average | Maximum | | | | |
| 51 | Persea Americana | 20 | | 30 | | 0 | | |
| 52 | Phoenix dactylifera | | | | | 0 | | |
| 53 | Phoenix reclinata | 900 | | 5000 | | 0 | | 11, 12 |
| 54 | Pinus patula | 110000 | 143000 | 170000 | 75-85 | 0 | 35-60 | 9, 10 |
| 55 | Pinus radiate | 33000 | | 50000 | 45 | 0 | | 11, 12 |
| 56 | Podocarpus gracillior | 2100 | | 2600 | 30 | 2 or 6 | 50-90 | 4, 5 |
| 57 | Prosopis juliflora | 8000 | | 35000 | 40-90 | 1 | 14 | 2, 3 |
| 58 | Prunus persica | | | | | | | |
| 59 | Psidium guara | 450000 | | 550000 | | 0 | 30 | 12, 1, 2 |
| 60 | Rhamnus prinoides | | | | | 0 or 7 | | 10, 11 |
| 61 | Ricinus communis | | | | | 0 | | |
| 62 | Schinus molle | 30000 | | 44000 | 40-90 | 0 | 10-30 | 1, 2 |
| 63 | Sesbania sesban | | 110000 | | 50-90 | 0 or 1 | 2-10 | 2, 3 |
| 64 | Spathodea nilotica | | 150000 | | | 0 | | |
| 65 | Syzygium guineense | 3000 | | | | | 40-50 | |
| 66 | Ziziphus mauritania | | | | 80-90 | 2 or 7 | | 2, 3 |
| 67 | Ziziphus spina-chrish | | | | 34-90 | 2 or 9 | | 3, 4 |

**Remark**

0 If the seed is collected immediately doesn't need any pre treatment
1 After soaking the seed in hot water, leave it to cool down for about 18 hours
2 Piercing or mechanical scarification of the seed
3 Soaking in cold water for 12-18 hours
4 Soaking in hot water for 2 minutes
5 Soaking in cold water for 2 days
6 After soaking the seed in hot water leaving it to cool for 12 hours
7 After soaking the seed in hot water for 5 minutes leaving it to cool for 24 hours
8 Pricking
9 After soaking the seed in hot water for 5 minutes putting the seed in cold water for 24 hours

**Sowing time**

| | | |
|---|---|---|
| 1 January | 5 May | 9 September |
| 2 February | 6 June | 10 October |
| 3 March | 7 July | 11 November |
| 4 April | 8 August | 12 December |

*Annex 2. List of tree species, suitable environment, propagation methods and their uses*

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| 1 | Acacia abyssinica (Indigenous) | Am: (bazra girar), Or: Gerbi Tg: Cheha English: Umbrella thorn | Family: Fabaceae-mimosoideae Life form: (large tree), Height: Upto 20m, | Altitude: 1500-2800 masl, Rainfall: 1000-2000 mm, AEZ: dry, moist and wet woina dega and wet and moist dega | Propagation method: direct sowing of seeds, seedlings; root suckers. Pre sowing treatment is by soaking the seeds in cold water or put in hot water and then allow to cool for 36-48 hours | Products: Fire wood, Timber, Bee forage, medicine and Fodder |
| | | | | | Seed management: Seed can be stored for long periods if kept in a cool, dry and insect-free place.; Number of seeds is about 16,000-18,000/kg | Services: Erosion control, nitrogen fixation , shade and shelter |
| 2 | Acacia brevispica (Indigenous) | Am: (Kontevl, Mezazign, Qanter, Qwentr ), | Height: slender tree to 7 m | Altitude: 900-2000 masl, AEZ: Moist and Dry Kolla and Weyna Dega | Propagation method:Seedlings, direct sowing,Pre sowing treatment: Immerse in hot water and soak for 24 hours. | Products: Firewood, medicine (roots), fodder (pods and leaves), |
| | | | | | Management::Fairly fast growing. Coppicing. | |
| | | | | | Seed management: Seed stores well..; Number of seeds is about 7,000-9,000. /kg .Seed stores well | Services:livefence. |
| 3 | Acacia tortilis (Indigenous) | Am: Deweni grar | Family: Fabaceae Life form: ( tree), Height: 4-21 m | Altitude: 900-2000 masl AEZ:Dry and Moist Kolla and Weyna Dega | Propagation method:Seedlings, wildings.Pre sowing: Seed is very hard. Pour boiling water over seed and leave to soak for 24 hours. | Products:Firewood, charcoal, timber, poles, posts, fodder (shoots, leaves,pods), bee forage, |
| | | | | | Management:Slow-growing but if well managed it grows relatively fast on dry sandy soils. | Services::soil conservation, nitrogen fixation, shade |
| | | | | | Seed managementSeed can be stored for a very long period without losing viability. Number of seeds:12,000-31,000. | (livestock), fences (cut branches), fibre (bark). |
| 4 | Acacia decurrence (Exotic) | Amharic: (Akacha, mimosa, yeferenji girar, ) English: (Green wattle, king wattle, Sydney black wattle) | Family: Fabaceae-mimosoideae Life form: (Tree), Height: 6-12 m, | Altitude: 1600-3000 masl, AEZ: moist and wet woina dega and dega | Propagation method: Seed, root suckers; Pre sowing treatment is Immersing the seeds in boiling water and then cooling for 24 hours, germination rate is 50-70% | Products: Fire wood and charcoal , Timber, Bee forage, Tannin |
| | | | | | Seed management: Will store many years in a cool dry place; Number of seeds is about 45,000-95,000/kg. | Services: Nitrogen fixation , shade and shelter, Ornamental, Wind break |
| | | | | | Management: Seedlings should spend 7-8 months in the nursery before planting out. Will regenerate after coppicing. | |
| 5 | Acacia melanoxylon (Exotic) | Amharic: Omedla, English:Australian blackwood | Family: Fabaceae , Life form: (tree), Height: up to 35 m, | Altitude: 1500-2300 masl, Rainfall : 750-2300 mm, AEZ: Moist and wet woina dega and dega | Propagation method: by seeds and branch cutting, germination 10-30 days, germination rate is 55-90 %. | Products: Fire wood and charcoal , Timber, forage, (leaves) |
| | | | | | Tree management: Lopping, pollarding. | Services: Erosion control, shade and shelter, Nitrogen fixation |
| | | | | | Seed management: Can be stored for 20 years, No. of seeds per kg: 55,000-85,000. | |
| 6 | Acacia nilotica (Indigenous) | *Amh:Cheba Eng: Egyptian thorn* | Height:2-6 m | Altitude: 600-1,700. RF:500-900 AEZ: Dry and Moist | Propagation method: Seed, direct sowing, seedling, pre-treatment not necessary for fresh seed. Nick stored seed or soak in coldwater for 24 hours. | Product:Firewood, charcoal, poles, medicine Fodder, bee forage. |
| | | | | Kolla | Tree management: Medium to fast-growing on good sites, lopping, pollarding. | Services: fixation, soil conservation , windbreak, live fence, |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | | | | Seed management: Seed stores well.Germination rate 60-90%;no. of seeds per kg: 7,000-11,000. | |
| 7 | Acacia meamsii (Exotic) | Amh:Mimosa<br>Eng: Black wattle | Height: 2-15 m | AEZ: Moist and Wet Weyna Dega and Dega | Propagation: seed, direct sowing, seedling, pre-seed treatment: Immerse in boiling water and cool for 24 hours. | Product: Firewood, charcoal, medicine, bee forage, |
| | | | | | Tree management : Thin if established by direct sowing. | Services: soil conservation, nitrogen fixation, ornamental, windbreak, fibre, tannin. |
| | | | | | Seed management: Seed can be stored for long periods. No. of seeds 50,000--85,000/kg | |
| 8 | Acacia polyacantha (Indigenous) | Amharic: *Gmarda Tirigna: Gumero*<br>English:*Falcon's-claw acacia*. | Family: Fabaceae ,<br>Life form: (Large deciduous tree)<br>Height: up to 25 m | Altitude: 500–1,600 masl,<br>AEZ: dry and moist kolaMay indicate fertile soil and Groundwater but can also grow on stony soil. | Propagation method:Seedlings, direct sowing.Pre-treatment: Not need. | Products: Fire wood and charcoal , farm tools, Timber, Medicine, fodder |
| | | | | | Tree management: Fast growing on good sites; pollarding, coppicing. The wood is termite resistant. | Services: Erosion control, Nitrogen fixation, Ornamental, soil improvement, live fence. |
| | | | | | Seed management: Long term storage, Seed can be stored if kept cool, dry and insect-free.No of seeds/kg: 14,000-16,000. | |
| 9 | Acacia saligna (Exotic) | Amharic: (Saligna girar),<br>English: (willow wattle, weeping wattle, Port Jackson willow, orange wattle, golden-wreath wattle, blue-leafed wattle) | Family: Fabaceae ,<br>Life form: (Short lived perennial),<br>Height: up to10m | Altitude: 1000-2400 masl,<br>Rainfall: 400-2500 mm,<br>AEZ: Dry and Moist Kolla and Dry Weyna<br>Dega | Propagation method: Direct seeding is best; Pre-treatment: Immerse in boiling water and cool for 24 hours.Germination rate: 55-90%. Germination date: 2-3 weeks | Products: Fodder, bee forage, Fuel wood, Fibre, Timber, Medicine, Light construction |
| | | | | | Tree management: Pruning to 0.5-1m; weeding | Services: Erosion control, Shade or Shelter, Nitrogen fixation, Soil improvement, Intercropping |
| | | | | | Seed management: Long term storage, Can be kept for one or two years in a cool dry place.No of seeds/kg: 14,000-80,000. | |
| 10 | Acacia Senegal (Indigenous) | Amharic: (kontir, sbansa-girar),<br>English: (gum arabic, Sudan gum arabic, gum acacia, three-thorned acacia) | Family: Fabaceae - Mimosoideae,<br>Life form: (deciduous shrub),<br>Height: up to 15 m, | Altitude: 100-1700 masl<br>Rainfall: 300-1200 mm,<br>AEZ: Dry and moist kolla | Propagation method: Direct sowing, seedlings, and cutting; fresh seeds do not need treatment, but seeds older than 1 year need nicking or soaking seeds in cold water for 24 hours.Germination rate is low. | Products: Fodder (Leaves and pods), Gum and resin, , Fuel wood and charcoal, essential oil |
| | | | | | Tree management: needs weeding and protection from animals during early stages, lopping, coppicing. | Services: Desertification control, rehabilitation, Wind erosion control, Intercropping |
| | | | | | Seed management: Seed stores well in a cool, dry and insect-free place ; number of seeds is 8,000-11,000 /kg | |
| 11 | Acacia seyal (Indigenous) | Amharic:Wachu,<br>English: White-galled acacia, White whistling thorn | Family: Fabaceae,<br>Life form: (Small to medium tree) Height: up to9 m, | Altitude: 1,200-2,100 masl,<br>Rainfall: 300-1200 mm,<br>AEZ: dry and moist woina dega | Propagation method: seedlings and direct sowing; pre-treatment is not necessary for fresh seed. Nick stored seed or soak in coldwater for 24 hours. | Products: Fodder (Leaves, leaves and pods), Bee forage, Fuel wood and charcoal, Timber, Rope (bark), Gum and incense |
| | | | | | Tree management: Medium to fast growing; lopping, pollarding, coppicing. | Services: Shade and shelter, Fences |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | | | | Seed management: Seed can be stored for three months if kept cool, dry and insectfree. number of seeds is ± 20,000/kg | |
| 12 | Albizia gummifera (Indigenous) | Amharic: Sessa<br>English: *Peacockflower* | Family: Fabaceae-Mimosoideae),<br>Life form: ( Large deciduous tree),<br>Height: about 15m high | Altitude: 1,600-2500 masl,<br>AEZ: Dry, moist and wet woina dega | Propagation method: Seedling, direct sowing and wildlings; pre-treatment of fresh seeds not necessary but stored seeds need to be soaked in warm water and left to cool, germination rate is 70-80% within 10 days | Products: Fuel, Timber, Medicine |
| | | | | | Tree management: Lopping, coppicing while young. | Services: Erosion control, Shade or shelter, Nitrogen fixation, Soil improvement, Ornamental, Boundary or barrier or support, Intercropping |
| | | | | | Seed management: Seed can be stored up to a year before losing viability.Susceptible to insect attack therefore seed should be collectedwhile still on the tree.<br>number of seeds is 10,000-14,000 seeds/kg | |
| 13 | Albizia shimperiana (Indigenous) | Amharic: (sassa, Imasa, Sembaru)<br>English: (large podded albizia) | Family: Fabaceae-Mimosoideae), Life form: (large semi-deciduous tree), Height: Up to 25m, | Altitude: 1400-2200 masl,<br>AEZ: moist and wet woina dega | Propagation method: Seeds, seedlings and wildlings; pre-sowing treatment is not necessary, seedlings should be planted when they reach 4 months | Products: Firewood and charcoal, Timber, Bee forage |
| | | | | | Tree management: Coppicing, Pollarding | Services: Erosion control, Shade and shelter, Nitrogen fixation |
| | | | | | Seed management: Seed storage behaviour is orthodox, seeds store for a long time if kept cool, dry, and insect free... Number of seeds is on the average 8000/kg | |
| 14 | Aningeria altissima (Indigenous) | Amharic: *Kerero* | Life form and Height: A tall tree to 45 m, | Altitude: 1,000-1,700m.<br>AEZ: Moist and Wet Kolla and Weyna Dega | Propagation method: seed, seedling, wildings, seed pretreatment not necessary. | Use: Firewood, timber (furniture, veneer). |
| | | | | | Tree management: Relatively fast growing. Weeding, pruning. | Services: |
| | | | | | Seed management : Seeds lose viability very quickly; need to sow it fresh.No. of seeds per kg: 1,000. | |
| 15 | Annona muricata (Exotic) | Amharic:Gishta<br>English: *Sour soup* | Life form and Height:A slender tree 5-7 m | Altitude: 900-1,500 m.<br>AEZ: Dry, Moist and Wet Kolla agroclimatic zones, | Propagation method:Seedlings. Treatment not necessary | Products:<br>Food, drink, medicine, , insecticide, fish poison. |
| | | | | | Tree management: Regular weeding, pruning above 1 m to encourage branching. | Services: ornamental |
| | | | | | Seed management: Can be stored for several months | |
| 16 | Annona senegalensis (Indigenous) | Amharic: Giishta, Yebere lib<br>English: *Wild custard apple* | Life form and Height :A shrubby tree, 2-10 m | Altitude: 500-1,600 m<br>AEZ: Moist and Wet Kolla | Propagation method:Seedlings, wildings. Pretreatment Not necessary. | Products: Firewood, timber, poles, tool handles, food (fruit), medicine (roots, gum, fruit), fodder (leaves, fruit), fibre (bark), yellow-brown dye (bark). |
| | | | | | Tree management: | Services: ornamental, windbreak, |
| | | | | | Seed management : Can be stored. No. of seeds per kg: 3,000-4,000. | |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | | | | | |
| 17 | Antiaris toxicaria (Indigenous) | | Height: 20- 40 m | Altitude: 1 350-1 700 m | Propagation: seed, these seeds require no pretreatment. However they lose viability very fast and should be sown as soon as collected. About 70-90% of sown seeds germinate in 18-89 days. | Products: fuel wood, food, medicine |
| | | | | | Tree management: fast growing, has a good self-pruning ability. | Services: Shade, shelter, soil improver, intercropping |
| | | | | | Seed management : under natural conditions, the seeds lose viability rapidly, | |
| 18 | Arundinaria alpine (Indigenous) | Amharic: (Kerkeha), English: (Mountain bamboo) | Family: Gramineae, Life form: (Grass), Height: usually 6-8 m but can reach 12-25 m. | Altitude: Up to 3300 masl AEZ: Moist and wet dega | Propagation method: Rhizomes, natural regeneration, seeds seedlings | Products: Construction, Local furniture, local spinning tools, basketry |
| | | | | | | Services: Erosion control, Boundary or barrier or support |
| 19 | Arundo donax (Indigenous) | Amharic: (Shembeko, Meka), English: (Reed grass) | Family: Gramineae, Life form: (Grass), Height: 2-6m, Stem diameter: | Altitude: Up to 2400 masl, AEZ: Moist and Wet Kollaas well as in Dry, Moist and Wet Weyna Dega | Propagation method: Rhizomes, natural regeneration, | Products: Fodder, local furniture, local spinning tools, basketry, Fences, Grain store |
| | | | | | | Services: Erosion control |
| 20 | Azadiractha indica (Exotic) | Amharic: (Kinin), English: (Persian lilac, neem tree, bastard tree, Indian lilac, bead tree, margosa tree, cornucopia, Indian cedar) | Family: Meliaceae, Life form: (small to medium-sized tree), Height: may reach 20m | Altitude: 400-2,000 m a s l.Rainfall: 700-2,500 mm AEZ: Dry and Moist Kolla and Moist Weyna Dega | Propagation method: Seed, root suckers and coppice; seed treatment not necessary but scarification improves germination rate | Products: Food, Timber, tannin or dyestuff, Poison, Medicine |
| | | | | | Tree management: Protection from fire and browsing | Services: |
| | | | | | Seed management: Seed should not be stored as it loses viability quickly. number of seeds is 2,000-8,000 seeds/kg | |
| 21 | Borassus aethiopum (Indigenous) | Amharic: (zembaba), English (borassus palm, palmyra palm, African fan palm, ron palm, deleb palm, fan palm) | Family: Arecaceae, Life form: (un-branched palm ), Height: Up to 25 m, Stem diameter: | Altitude: 0-1,200 masl Rainfall: 500-1,400 mm, AEZ: moist and wet kola and woina dega | Propagation method: Seed; pre-treatment is not necessary, germination can take 1 month | Products: Food (Fruit), Fodder (Fruit and young leaves), Bee forage, Firewood and charcoal, Fibre and Timber, Alcohol, Medicine, Ornamental |
| | | | | | Tree management: Coppicing, pollarding and lopping | Service: |
| | | | | | Seed management: Seeds have a very short period of viability and should be sown directly after they are removed from the pulp, number of seeds is 2-3 seeds/kg | |
| 22 | Boswellia papyrifera (Indigenous) | Amharic: (Qererrie, yetan zaf), English (Bitter frankincense ) | Family: Burseraceae, Life form: (deciduous tree), Height:4-12m, | Altitude: 950-1800masl Rainfall: AEZ: dry kola | Propagation method: seedlings and cuttings | Products: Insane , Medicine, Bee forage |
| | | | | | | Services: Reclamation |
| 23 | Calliandra calothyrsus (Exotic) | | Family: Fabacea Height: small tree (2-12 m) | Altitude: 0-2000 masl Rf:250-1300 | Propagation: seed, stem cuttings. Seed requires scarification. Good result achieved by soaking in cold water for 48 hours | Products: Fodder, fuel, apiculture |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | | | | | Services: Erosion control, shade or shelter, nitrogen fixing, soil improver, intercropping, ornamental |
| | | | | | Seed management: seed viability maintained for serveral years in hematic storage | |
| 24 | Capparis tomentosa (Indigenous) | Amharic: (gumero ), English (woolly caper-bush ) | Family: Capparidaceae Life form: a spiny scrambler or a small tree Height: Up to 10 m, Stem diameter: 13-15 cm | Altitude: 1,200-2,300 masl Rainfall: AEZ: dry and moist kola and woina dega | Propagation method: Artificial regeneration is by seedlings and cuttings | Products: Food (fruit), Firewood, Poison |
| | | | | | Tree management: Lopping | Services, Boundary or barrier support |
| | | | | | Seed management: | |
| 25 | Casimroa edulis (Exotic) | Amharic: (Cashmir), English (casimiroa, Mexican apple, mexican sapote, white sapote, white zapote) | Family: Rutaceae, Life form: (evergreen tree),Height: up to 18m , Stem diameter: | Altitude: 1200-2400 masl Rainfall : AEZ: | Propagation method: Seeds, seedlings, grafting | Products: Food, Timber, Medicine |
| | | | | | Tree management: Pruning | Services |
| | | | | | Seed management: | |
| 26 | Casuarina cunninghamiana (Exotic) | Amharic: (*Shewshewe*, *Arzelibanos*), English (Australian beefwood, Australian pine, beefwood, casuarina, coast beefwood, creek oak, Cunningham beefwood, fire oak, river she-oak, river oak ) | Family: Casuarinaceae, Life form: (a medium to large tree), Height: 12-35 m | Altitude: 1500-2800 masl Rainfall: 500-1500 mm, AEZ: Dry and moist woina dega and dega | Propagation method: From seeds, germination rate is 55-90%, no need for pre treatment | Products: Foddder, Firewood and charcoal and Timber |
| | | | | | Tree management: Coppicing when young | Services: Riverbank protection, Windbreak and shelterbelt |
| | | | | | Seed management: Seed can be stored for up to a year, Number of seeds is 1,400,000-1,600,000/kg | |
| 27 | Casuarina equisetifolia (Exotic) | Amharic: (arzelibanos, shewshewe), English: (Australian beefwood, beach she-oak, whistling pine, beefwood tree, common, swamp she oak, casuarina, she oak, wild pepper, sea pine, coast she-oak, horsetail casuarina) | Family: Casuarinaceae, Life form: (an evergreen, dioecious or monoecious), Height: 6-60 m , Stem diameter: 100-150cm | Altitude: 0-1400 masl Rainfall: 200-3500 mm, AEZ: Dry, Moist, and Wet Kolla | Propagation method: From seeds | Products: Firewood , Fibre, Timber, Tannin or Dyesluf, Medicine |
| | | | | | Tree management: Coppicing when young, pruning and thinning | Services: Erosion control, Shade or shelter, Reclamation, Nitrogen fixation, soil improvement, Ornamental, Boundary or barrier support, Intercropping |
| | | | | | Seed management: Seed storage behaviour is orthodox, Number of seeds is up to 600,000-900,000./kg | |
| 28 | Celtis Africana (Indigenous) | Amharic: (Amlaka, Kawoot), | Family: Ulmaceae, Life form: (deciduous | Altitude:1300-2200 masl Rainfall: | Propagation method: Seedlings | Products: Firewood , Timber, Tool handles, Fodder |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | English: ( ) | forest tree),<br>Height: 12-35m,<br>Stem diameter: | AEZ: dry and moist kolla and woina dega : | Tree management: Side pruning | Services:Shade or Shelter |
| 29 | Chamaecytisus palmensis (Exotic) | Amharic: (Tree lucern) English: (tree lucern ) | Family: Fabaceae – Papilionoideae<br>Life form: (evergreen shrub or small tree )<br>Height: 5-8 m<br>Stem diameter: | Altitude: 1,700-3,300masl<br>Raiinfall: 350-1500 mm<br>AEZ: Moist and Wet Weyna Dega and Dega | Propagation method:Direct sowing, seedling, pre-treatment is scarification or treating with boiling water for 1 minute, seeds germinate 7-14 days<br>Seeds can be stored for 4-5 years.<br>No. of seeds: 42 600 seeds/kg | Products: Fodder: leaves and fine stem, Bee forage, Firewood<br>Services: Erosion control, Reclamation, Hedges, Alley cropping |
| 30 | Combretum molle (Indigenous) | Amharic: (agalo, avalo ) English: (velvet leaf willow, velvet leaf combretum, velvet bush willow ) | Family: Combretaceae<br>Life form: (a shrub or small, graceful, deciduous tree )<br>Height: up to 15 m | Altitude: 500-2200 masl<br>Rainfall: 900-1200 mm<br>AEZ: Dry and Moist Kolla and woina dega | Propagation method: Seeds; seedlings and root suckers, seed treatment Not necessary, seed germinates easily, open fruit to getseed.<br>Tree management: coppicing and lopping<br>Seed management: Seed can be stored for only a very short period. Sow freshseed for best germination results.; Number of seeds is 10,000-15,000/kg | Products: Fodder: leaves, Bee forage, Firewood and charcoal, Timber, Tannin or Dyestuff, Medicine<br>Services: Soil improver |
| 31 | Cordia africana (Indigenous) | Amharic: (Wanza ) , English: (Sudan teak, East African cordia, large-leafed cordia ) | Family: Boraginaceae ,<br>Life form: (a small to medium-sized evergreen tree ), Height: 4-30 m, Stem | Altitude: 1,600-2,200 masl,<br>Rainfall: 700-2000 mm<br>AEZ: Dry, Moist and Wet WeynaDega | Propagation method:direct sowing, Seedling, pre-treatment is soaking in cold water for 6 hours and germinate within 40-60 days; germination rate is 50-80%. Seedlings require 4-6 months in a nursery before planting out<br>Tree management: pollarding, lopping and coppicing<br>Seed management: Dried seeds can be stored for 1 year, Number of seeds is 2500-4500 seeds/kg | Products: Food, Fodder, Bee forage, Firewood , Timber, Medicine<br>Services: Shade or Shelter, Soil improve, Ornamental |
| 32 | Croton macrostachyus (Indigenous) | Amharic: (Bisana), English: (broad-leaved croton ) | Family: Euphorbiaceae,<br>Life form: (a deciduous tree ),<br>Height: 3-25 m, | Altitude:1100-2500 masl<br>Rainfall: 150-1200 mm,<br>AEZ: dry, moist and wet woina dega and dega as well as in upper altitude of dry kola | Propagation method: Seeds, coppicing, wildings and seedlings, No need of pre sowing treatment but check for viability of seeds since the inside must be white-cream colored.; seeds germinate within 30-60 days, with an expected germination rate of about 40-70%.<br>Tree management: pollarding, lopping and coppicing<br>Seed management: Seeds can be stored for two years if properly dried, Number of seeds is 16,000-27,000/kg | Products: Fuel wood, Timber, Medicine, Fodder (Leaves), Bee Forage<br>Services: Erosion control, soil improver, Agroforestry |
| 33 | Cupressus lusitanica (Exotic) | Amharic: (yeferenji-tid), English: (cypress, cedar of Goa, Mexican cypress, Kenya cypress ) | Family: Cupressaceae,<br>Life form: (an evergreen),<br>Height: Up to 35 m,<br>Stem diameter: | Altitude:1000-4000 masl,<br>Rainfall: 800-1500 mm,<br>AEZ: Dry, Moist, and wet woina dega and dega | Propagation method: Seeds; Pre-sowing treatment is not necessary; germination takes 20-30 days and the germination rate is ±90%.<br>Tree management: Weeding, pruning and thinning<br>Seed management: Seed can be stored for 6 months. Number of seeds is 160,000-290,000/kg | Products: Fuel wood, Timber<br>Services: Shade or shelter, Ornamental, Boundary or barrier support |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| 34 | Delonix regia (Exotic) | Amharic: (dire dawa zaf), English: (flamboyant flame tree, gold mohur, flame tree, julu tree, peacock flower, flame of the forest, gul mohr, flamboyant, royal poinciana ) | Family: Fabaceae – Caesalpinioideae, Life form: (a tree), Height: 10-18 m, Stem diameter: | Altitude:200-1,600 m., Rainfall : 700-1200 mm, AEZ: Widely planted in Bereha and Dry and Moist Kolla | Propagation method: Seeds; Seedlings; pre-treatment is practiced as a small portion of the seed coat is clipped, or seeds are boiled in hot water, then allowed to soak for 24 hours, germinate within 5-10 days, with a germination rate of up to 90%. | Products: Bee forage, Fuel wood, Timber, Gum and resin, Medicine |
| | | | | | Tree management: Pollarding, pruning, | Services: Sade or shelter, Boundary or barrier support |
| | | | | | Seed management: Seed can be stored for long periods as it is not damaged byinsects.; Number of seeds is 2000-3245/kg | |
| 35 | Dodonaea angustifolia ((Indigenous) | Amharic: *Kitkita* *English: Hop bush* | Height: 3-8 m | Altitude: 1,100-1,800 m. AEZ: Dry and Moist Kolla and lowerWeyna Dega | Propagation method:Seedlings, wildings, direct sowing. Pre-treatment not necessary Germination rate 30-70 %. | Product: Firewood, charcoal, poles, tool handles, medicine (leaves, roots) |
| | | | | | Tree management: Fast growing. Little or no management required once established. | Services: bee forage, soil conservation, windbreak, live fence. |
| | | | | | Seed management:Seed can be stored for up to a year., No. of seeds per kg: ±100,OOO. | |
| 36 | Dombeya torrida (Indigenous) | Amharic: (Wulkifa), English: () | Family: sterculiaceae, Life form: (shrub or much branched tree), Height: 12-15m | Altitude:1600-3400 masl, AEZ: dry, moist and wet woina dega, moist and wet dega and moist wurch | Propagation method: Seedlings; no pre-sowing seed treatment | Products: Firewood, Timber, Poles, Farm tools, Bee forage, Fibre |
| | | | | | Tree management: Coppicing, pollarding, lopping | |
| | | | | | Seed management: | Services: Soil Improver |
| 37 | Dovyalis abyssinica (Indigenous) | Amharic: (Koshim), English: () | Family: Flacourtiaceae, Life form: (evergreen spiny shrub or tree ), Height: Up to 8m , | Altitude:1600-2200masl, Rainfall :500-1500mm, AEZ: Moist and Wet Weyna Dega | Propagation method: Seeds, seedlings, Pre-treatment is after soaking the fruit in cold water for 24 hours break up the flesh to release the seeds | Products: Food, Fodder, Bee forage, Timber, Poison |
| | | | | | Tree management: Lopping, coppicing | Services: Ornamental, Boundary or barrier support |
| | | | | | Seed management: Seeds store well | |
| 38 | Ekebergia capensis (Indigenous) | Amharic: (lol, sombo ), English: (Dog plum, ekeberiga, Cape ash) | Family: Meliaceae, Life form: (an evergreen or semi-deciduous, medium-sized to large tree), Height: 7-35 m | Altitude:1400-3000 masl, Rainfall: 750-2000 mm, AEZ: dry, moist and wet woina dega and dega | Propagation method: Seeds, wildlings and cuttings; No pre-sowing treatment, seeds germinate in 8-9 weeks; germination rate ranges from 40-90% | Products: Fodder, bee forage, Fuel wood and charcoal, Tannin or Dyestuff, Medicine |
| | | | | | Tree management: Fairly fast growing. | |
| | | | | | Seed management: Seeds do not store for long.; Number of seeds is 2900-8600/kg | Services: Erosion control, Shade or Shelter, Ornamental, Intercropping |
| 39 | Ensete ventricosum | Amharic:Enset Eng: *Wild banana* | Height: 6-12 m | Altitude: 1,600-3000 m AEZ: Moist and Wet Weyna Dega and Dega | Propagation: suckers | Food, ornamental, fibres, thatch (leaves), |
| | | | | | | Service: soil conservation |
| 40 | Entada abyssinica (Indigenous) | Amharic: (kontir, kentefa), English: (tree entanda) | Family: Fabaceae – Mimosoideae , Life form: (a small to medium-sized, deciduous tree), Height: 3-15 m, Stem | Altitude:1300-2050 masl, Rainfall: 500-1400 mm, AEZ: dry, moist and wet kola and woina dega | Propagation method: Seeds; Seed germination rate is 70-100% | Products: Fodder, Fuel, Timber, Tannin or Dyestuff, Poison, Medicine |
| | | | | | Tree management: Coppicing | Services: Shade or shelter, Nitrogen fixation, Ornamental, Intercropping |
| | | | | | Seed management: Seed storage behavior is orthodox ; Number of seeds is 3600-4200/kg | |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | | diameter: | | | |
| 41 | Erythrina abyssinica (Indigenous) | Amharic: (kuara, korch, korra), English (Uganda coral, red-hot-poker tree, erythrina, flame tree, lucky bean tree, kaffir boom) | Family: Fabaceae – Papilionoideae , Life form: (medium-sized tree), Height: 5-15 m, | Altitude:500-2,000 masl Rainfall: 800-2000 mm AEZ: Moist and Wet Kalla and Weyna Dega | Propagation method:Seedlings, cuttings, direct sowing. Propagation from cuttingsis successful if done immediately after the rainy season.Seed treatment not necessary.Germination ±70 %.<br>Tree management: Pollarding, coppicing and pruning<br>Seed management: The seeds may be stored for long periods without losing viability if kept cool, dry and insect free; No. of seeds per kg: ±6,800. 3,600-4,200. | Products: Fodder,Bee forage, Fuel, Timber, Tannin or Dyestuf, Poison, Medicin<br>Services: Erosion control, Shade or shelter, Nitrogen fixation, Soil Improver, Ornamental, Boundary or barrier support, Intercropping |
| 42 | Erythrina brucei (Indigenous) | Amharic: (Korch, Ergofit, Kermo ayderk), | Family: Fabaceae – Papilionoideae , Life form: (small deciduous tree), Height: usually 5-10 m: | Altitude:500-2000 masl, Rainfall: 1000-2000 mm, AEZ: moist and wet kolla and woina dega | Propagation method: Seedling, Cutting; Pre-treatment not necessary, Germination rate is low. No. of seeds per kg: ±6,800.<br>Tree management: Pollarding, coppicing<br>Seed management: Seed can be stored for long periods if kept cool, dry and free from diseases | Products: Fire wood, Medicine, Fodder, Bee forage<br>Services: Nitrogen fixation, Mulch, Erosion control, Ornamental, Ceremonial, Necklace (seed) |
| 43 | Euphorbia abyssinica (Indigenous) | Amharic: (kulkual), | Family: Euphorbiaceae, Life form: (succulent leafless tree ), Height: Up to 20m | Altitude:1,400-2,400 m, usually above 1,900 m Rainfall: AEZ: dry, moist and wet woina dega | Propagation method: Cutting | Products: Firewood, Timber, Medicine |
| 44 | Euphorbia candelabrum (Indigenous) | Amharic: (Kulkual ), | Family: Euphorbiaceae, Life form: (succulent tree) Height: Up to 15 m Stem diameter: | Altitude:1,200-2,200 m., Rainfall: 800-2000mm AEZ: dry and moist kolla and woina dega | Propagation method: Cutting | Products: Firewood, Timber, Latex |
| 45 | Euphorbia tirucalli (Indigenous) | Amharic: (kinchib), English: (finger euphorbia, Indian spurge tree, milk bush, pencil tree, rubber euphorbia), | Family: Euphorbiaceae, Life form: (Shrub or small tree), Height: 4-12 m, Stem diameter: | Altitude:1400-2500 masl Rainfall: AEZ: dry and moist woina dega and dega | Propagation method: Branch cutting<br>Tree management: Fast growing. Coppicing, trimming and top pruning to make a fence. | Products: Fuel, Timber, Gum or resin, Latex or rubber, Poison, Medicin<br>Services: Erosion control, Reclamation, Ornamental, Boundary or barrier support, Intercropping |
| 46 | Faidherbia albida (Indigenous) | Amharic: (Girar), English: (white-thorn, white acacia, apple ring acacia, apple ring tree, gao, ana tree, winter thorn), | Family: Fabaceae - Mimosoideae , Life form: (tree), Height:30m , | Altitude: Up to 2700 Rainfall: 250-1200 mm AEZ: dry, moist and wet woina Dega | Propagation method: Seeds, direct sowing, seedlings; Seed treatment is nicking the seed or soaking in water for 24 hours, germination rate is 40-60% and seeds germinate from 6-30days<br>Tree management: Pruning, Lopping, coppicing<br>Seed management: Can be stored indefinitely if kept cool, dry, and insects free.; Number of seeds is from 11,500-20,000/kg | Products: Fodder (leaves and pods), Bee forage, Firewood and charcoal, Timber, Medicine<br>Services: Shade or shelter, Reclamation, Ornamental, Boundary or barrier support |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| 47 | Ficus sur (Indigenous) | Amharic: (shola) English (Cape fig) | Family: Moraceae Life form: (large tree ) Height: up to 30m Stem diameter: upto150cm | Altitude:1400-2500 masl Rainfall: 1000-2000mm AEZ: moist and wet woina dega | Propagation method: Cuttings | Products: Timber (local furniture, boxes),food (fruit),, Medicine |
| | | | | | Tree management: Lopping, pollarding | Services: Shade or shelter, Ceremonial |
| 48 | Ficus sycomorus (Indigenous) | Amharic: (shola, bamba ) English: (wild fig, strangler-fig, Sycamore, sycamore fig, bush fig, common cluster fig ) | Family: Moraceae Life form: (semi-deciduous spreading savannah tree), Height:21-46 m, Stem diameter: | Altitude:500-2000m Rainfall: 500-2200 mm, AEZ: dry, moist and wet woina Dega | Propagation method: Cuttings | Products: Food (fruits), Fodder (leaves), Firewood and charcoal, Fibre, Timber, Medicine |
| | | | | | Fairly fast growing. Pruning, lopping to reduce shade. | Services: Erosion control, Shade or shelter, soil improver, Ornamental, Intercropping |
| | | | | | Seed management: Viable seed is difficult to obtain | |
| 49 | Ficus thonningii (Indigenous) | Amharic: (chibha) English: (strangler fig, common wild fig, bark-cloth fig) | Family: Moraceae, Life form: (evergreen tree) Height:6-21m Stem diameter: | Altitude:500-2000m Rainfall : 1000-2500 mm AEZ: | Propagation method: Seeds, seedlings, cuttings | Products: Fodder (fruit), Fodder (leaves and twigs), Fuel, Fibre, Timber, Latex, Medicine |
| | | | | | Tree management: Pruning, Lopping | Services: Erosion control, shade and shelter, Soil improver, Intercropping, Ornamental |
| | | | | | Seed management: | |
| 50 | Ficus vasta (Indigenous) | Amharic: (Warka), English () | Family: Moraceae Life form: (large tree) Height:20m Stem diameter: | Altitude:1000-2400masl Rainfall: AEZ: | Propagation method: | Products: Wood for carving, Medicine |
| | | | | | Tree management: | Services: Shade or Shelter |
| | | | | | Seed management: | |
| 51 | Gliricidia Sepum (Exotic) | | Height 2-15 m Small tree | Altitude: 01600 Rf 1200-2300 | Propagation: seed and cuttings. Pretreatment not necessary when fresh seeds are used. When not fresh soak in hot water overnight and plant immediately. Germination is 90-100% | Product: feed , medicinal, firewood, pigmentation of eggs. |
| | | | | | | Service: Living fences/hedges, green manure , shade |
| | | | | | Seed management: seed storage behaviour is orthodox. Viability is maintained for 12 months in open storage . 8,000 seeds/kg. | |
| 52 | Grevillea robusta (Exotic) | Amharic: (grevillea) English: (silk oak, southern silky oak, silver oak, silky oak, silk-oak grevillea, grevillea, river oak) | Family: Proteaceae Life form: (deciduous medium-sized to large tree) Height:12-40m Stem diameter: 80-120cm | Altitude:1500-2700m Rainfall: 600-1700 mm AEZ: dry, moist and wet woina dega and dega | Propagation method: Seeds, seedlings, cuttings; No need of seed treatment; germination rate is 60-80% and seeds germinate in 20-28 daysThe species is a prolific seeder. Seed is difficult to collect. | Products: Bee forage, Firewood and charcoal, Fibre, Timber, Gum and resin, Poison |
| | | | | | Tree management: Moderate to fast growing. Pollarding, lopping, coppicing andpruning. Only young trees coppice well. | Services: Shade or shelter, Soil improver, Reclamation, Ornamental, Intercropping |
| | | | | | Seed management: Seed can be stored for up to three months, but this period canbe extended if it is refrigerated; Number of seeds is from 70,000-110,000/kg | |
| 53 | Hagenia abyssinica (Indigenous) | Amharic: (Kosso) English (kousso, hagenia, cusso, | Family: Rosaceae Life form: (Tree) Height: Up to 20m: | Altitude:2300-3300 m Rainfall: 1000-1500 mm AEZ: moist and wet woina | Propagation method: Seedlings, wildlings; No seed pre-treatment necessary, germination rate is 40-60% and seeds germinate in 10-20 days | Products: Firewood and charcoal, Timber, Medicine |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | brayera, African redwood) | | dega and dega | Tree management: Pruning and pollarding | Services: Erosion control, Shade or shelter, soil improver, Ornamental |
| | | | | | Seed management: Seed stores for 6-12 months.; Number of seeds is from 400,000-500,000/kg | |
| 54 | Jacaranda mimosifolia (Exotic) | Amharic: (yetebmenja zaf) | Family: Bignoniaceae Life form: (deciduous tree) Height: Up to 20 m Stem diameter: 40-50 cm | Altitude:1300-2040 masl Rainfall: 900-1300 mm AEZ: Moist and Wet upper Kolla and Weyna Dega | Propagation method: Seeds, Seedlings,coppicing,wildings,cutting; No seed pre-treatment is necessary, germination rate is 50-92%. Seeds profusely. | Products: Bee forage, Fuel, Timber |
| | | | | | Tree management: Weeding, Coppicing | Services: Shade or shelter, Ornamental |
| | | | | | Seed management: Seed does not store well. Sow fresh seed for best germinationresults; Number of seeds is 63,000-80,000/kg | |
| 55 | Jatropha curcas (Exotic) | Amharic: (jatropha) English (curcas, Barbados nut, pig nut, physic nut, castor oil, purging nut, fig nut, wild oil nut, Chinese castor oil) | Family: Euphorbiaceae Life form: (perennial, monoecious shrub or small tree) Height: Up to 6 m Stem diameter: | Altitude:0-2000 masl Rainfall: 300-1000 mm AEZ: | Propagation method: Seeds, Seedlings, cutting; No seed pre-treatment is necessary, seeds germinate in 10 days | Products: Fuel, Tannin or Dyestuff, Lipids, Wax, Poison, Medicine |
| | | | | | Tree management: Weeding, Pruning | Services: Erosion control, Nitrogen fixation, soil improver, Boundary or barrier support |
| | | | | | Seed management: Seeds are oily and do not store for long | |
| 56 | Juniperus procera (Indigenous) | Amharic: (tid, tedh) English (pencil cedar, East African pencil cedar, East African cedar, cedar, African pencil cedar) | Family: Cupressaceae Life form: (Tree) Height:30-50m | Altitude:1500-3000 masl Rainfall: 400-1200mm AEZ: moist and wet woina dega and dega | Propagation method: Seeds, Seedlings, wildlings, seed pre-treatment is immersing the seed in hot water at 100 deg. C, for 1 minute or soaking in sulphuric acid for 10 minutes; germination rate is 60-70% within 25-80 days | Products: Bee forage, Fibre, Fuel, Timber, medicine, Lipids |
| | | | | | Tree management: Thinning, Pruning | Services: Shade or shelter, Ornamental, Boundary or barrier support |
| | | | | | Seed management: Up to a year if stored in a cool, dry place.; Number of seeds is 11,000-50,000/kg | |
| 57 | Leucaena leucocephala (Exotic) | Amharic: (Lukina) English (Jumpy-bean, wild tamarind, lead tree, white popinac, white lead-tree, horse tamarind) | Family: Fabaceae - Mimosoideae Life form: (small, variably shrubby and highly branched to medium-sized tree), Height:3-20 m | Altitude:0-2100 masl Rainfall: 650-3000mm AEZ: humid bereha and moist and wet kola and Weinadega | Propagation method: Seedlings and direct sowing; Seed pre-treatment is soaking in hot water for 2 minutes or nicking the seed coat , using a sharp tool like scalpel, knife or nail clipper, germination rate is 50-80% in 8 days | Products: Fodder, Bee forage, Fuel, Fibre, Timber, Gum or resin, Tannin or Dyestuff |
| | | | | | Tree management: Very fast growing. Lopping. It coppices well. | Services: Erosion control, Shade or shelter, Nitrogen fixation, soil improvement, Ornamental, Boundary or barrier support |
| | | | | | Seed management: Seed can be stored for long periods if kept dry and insect free; Number of seeds is about 13,000-34,000/kg | |
| 58 | Mangifera indica (Exotic) | Amh: Mango Eng: Mango | Height: 10-15 m. | Altitude: 500 to 1,800 AEZ:Dry, Moist and Wet Kolla | Propagation method: Seedlings, direct sowing, grafting. Pre-treatment not necessary, but nicking the hard seed coat helpsgermination.Germination rate 60-90 %. | Product: Firewood, fodder, food, bee |
| | | | | | Tree management: Lopping, grafting. For quicker growth and early production offruits, grafted material should be used. | Services: forage, ornamental, shade, windbreak, soil conservation, gum. |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | | | | Seed management: Seed can be stored for only one month at room temperature.For best results, fresh seed should be used.No. of seeds per kg: ±50. | |
| 59 | Melia azedarach (Exotic) | Amharic: () English: (azedarach, bead tree, China berry, China tree, Persian lilac, pride of India, syringa) | Family: Meliaceae Life form: (deciduous tree ) Height: A small tree 5-6 m, but can reach 10 m | Altitude: 0-2400 masl Rainfall: 350-2000masl AEZ: Bereha, and dry, moist and wet kolla and woina dega | Propagation method: Direct sowing , seedlings, cuttings or stumps; 85% germination may be expected in 2 months | Products: Fodder, fuel wood, timber, Lipids, Medicine, Poison |
| | | | | | Tree management: Lopping, Pollarding, Coppicing, pruning | |
| | | | | | Seed management: Seed can be kept for some time if stored in a cool place; Number of seeds is about 500-3000/kg | Services Shade or shelter, Intercropping ,Ornamental |
| 60 | Millettia ferruginea (indigenous) | Amharic: (Birbira), English: (Milletia) | Family: Papilionoideae, Life form: (a small tree ), Height: Up to 35m, | Altitude: 1000-2500 masl Rainfall : 1100-2000masl AEZ: moist and wet kolla as well as dry, moist and wet dega | Propagation method: Seedling and direct sowing; seed pre-treatment is not necessary; Germination is very good – up to 80% in 20 days | Products: Fodder,fuel wood, Timber, Poison |
| | | | | | Tree management: Lopping, Pollarding, Coppicing | Services: Erosion control, Shade or shelter, soil improver, Ornamental, Intercropping |
| | | | | | Seed management: Seed storage :Can be stored.; Number of seeds is about 6000-10,000/kg | |
| 61 | Moringa oleifera (Exotic) | Amharic: (shiferaw) English: (moringa tree, ben-oil tree, cabbage tree, clarifier tree, horse-radish tree, drumstick tree, West Indian ben) | Family: Moringaceae Life form: (small, deciduous tree) Height: Up to 10 m. | MARF: At least 500mm, Altitude: 500-1600 masl, AEZ: dry and moist kola | Propagation method: Seeds, Seedlings , Cuttings; No seed pre-treatment is required and seeds sprout readily in 1-2 weeks. Germination rate 60-70%. | Products: Food, Fodder, Bee forage, Firewood and charcoal, Fibre, Timber, Gum or resin, Tannin or Dyestuff, Lipids |
| | | | | | Tree management: Pruning, Pollarding, Coppicing | Services: Erosion control, Soil improver, Ornamental, Boundary or barrier support, Intercropping |
| | | | | | Seed management: Seed storage behaviour is Orthodox; Number of seeds is about 4000-5000/kg | |
| 62 | Moringa stenoptala (Indigenous) | Amharic: (shiferaw) | Family: Moringaceae Life form: (Tee) Height: 60-12m Stem diameter: Up to 60cm | Altitude: 600-2200 masl Rainfall: 500-1400mm AEZ: : dry and moist kola | Propagation method: Seeds, Seedlings , ; No seed pre-treatment is required: germination rate is 86-96% | Products: Food (Leaves and seeds), Fodder, Fuel |
| | | | | | Tree management: | Services: Ornamental, Boundary or barrier support, Intercropping |
| | | | | | Seed management: Seed storage behaviour is Orthodox; Number of seeds is about /kg | |
| 63 | Morus alba (Exotic) | Amharic: (yeferenji injori) English: (white mulberry, mulberry, Indian mulberry, Russian mulberry) | Family: Moraceae, Life form: (shrub or moderate-sized tree), Height:up to 35 m | Altitude: 1500-2300 masl Rainfall: 1500-2500mm AEZ: dry, moist and wet woina dega | Propagation method:Seedlings, cuttings (for large-scale planting), Coppicing, Seed pre-treatment is scarification or soaking in cold water for about a week. Poor germination. | Products: Food (leaves), Fodder, Fuel, Fibre, Timber, Alcohol, Tannin or Dyestuff, Essential oil, Medicine |
| | | | | | Tree management: Pruning, Coppicing | Services: Erosion control, Shade or shelter, Reclamation, Soil improver, Ornamental, Fire wood, Timber, Fodder |
| | | | | | Seed management: Can be stored a long time; Number of seeds is about 1.1 million/kg | |
| 64 | Moms mesozygia (Indigenous) | Amharic: *Injori* | Life form : deciduous tree Height: Up to 30 m | Altitude: 500-1,500m AEZ: Moist and Wet Kolla . | Propagation method: Seedlings, cuttings. Pretreatment: Soak in cold water for 12 hours. | Products Firewood, timber, fodder, |
| | | | | | Tree management: Lopping | Services: shade. |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | | | | Seed management: Can be stored. | |
| 65 | Olea Africana (Indigenous) | Amharic: (Woira) English (African wild olive,brown olive,Indian olive,olive,wild olive) | Family: Oleaceae Life form: (shrub or a small to medium sized tree) Height: 5-18m Stem diameter: | Altitude: 800-2500 masl Rainfall: AEZ: moist and wet woina dega and lower dega | Propagation method: Seeds, Seedlings , (difficult to raise). Seed treatment is not necessary for fresh seed. Soak old seed in water for 48hours to .remove the endocarpThe species is a poor seeder. Low germination rate. | Products: Food (seeds) Fodder, Fuel, Timber, Medicine |
| | | | | | Tree management:Slow growing. | Services: Reclamation, Ornamental |
| | | | | | Seed management: Seed can be stored for about two months; Number of seeds is about 2500-3500/kg | |
| 66 | Oxytenanthera abyssinica (Indigenous) | Amharic: (Shemel), English (Lowland Bamboo) | Family: Gramineae, Life form: (tall grass), Height: Up to 7m, | Altitude: 500-1600 masl Rainfall: AEZ: moist and wet kolla | Propagation method: Suckers and rhizomes, rarely seed | Products: Poles, Fodder, Walking sticks |
| | | | | | Tree management: Needs to be controlled by cutting back. | Services: Fence |
| 67 | Parkinsonia aculeate (Exotic) | *Am: Filfile, Ye eyerusalem eshoh Eng: Jerusalem thorn* | Height: 5-8 m | Altitude: 300-1,700 m. AEZ: Bereha, Dry and Moist Kolla and Weyna Dega | Propagation method:Seedlings, direct sowing. Pretreatment: Soak seed in hot water and allow to cool overnight. The species is a prolific seeder. Germination rate 30-70%. | Products: Firewood, charcoal, fodder |
| | | | | | Tree management: Fast growing. Pollarding. Seedlings are susceptible to attack bytermites and so young seedlings should be protected. | Services: bee forage, mulch, soil conservation, ornamental, shade, windbreak, live fence. |
| | | | | | Seed management:: Seed stores well for long periods in cool, dry, closed containers. No. of seeds per kg: 11,000-15,000. | |
| 68 | Persea americana (Exotic) | Amharic: (Avocado) English (fruit, avocado, avocado-pear, alligator pear) | Family: Lauraceae, Life form: (medium to large tree), Height: 9-10m Stem diameter: | Altitude: 1500-2200 masl Rainfall: 300-2500 mm AEZ: moist and wet woina dega | Propagation method: Seeds, Seedlings , grafting, budding, layering. Seed treatment not necessary. Seed sown fresh for best results. | Products: Food (fruits), Fodder (surplus fruit), Bee forage, Timber, Lipids, Essential oil, Medicine, Poison |
| | | | | | Tree management: Pruning | |
| | | | | | Seed management: Seed does not store well. Use fresh seed.; Number of seeds is 20-30/kg | |
| 69 | Phoenix reclinata (Indigenous) | Amharic: (selen, zembaba), English (Senegal palm, coffee palm, wild date palm, false date palm, feather palm, mukindu palm) | Family: Arecaceae, Life form: (Palm), Stem diameter: Upto 25cm, Height: 10-12 m | Altitude: 700-2600 masl Rainfall: 500-1500 mm AEZ: dry and moist kola, woina dega and dega | Propagation method: Seeds, Seedlings , suckers; Seed pre-treatment is not necessary; Germination occurs within 25-35 days | Products: Food, Fodder, Firewood and charcoal, Fibre, Timber, Gum or resin, Tannin or Dyestuff, Alcohol and Medicine |
| | | | | | Tree management: Pruning, thinning | Services: Erosion control, Ornamental |
| | | | | | Seed management: Seed stores very well; number of seeds is 900-5,000 /kg | |
| 70 | Phytolacca dodecandra (Indigenous) | Amharic: (Indod), English () | Family: Phytolacaceae, Life form: (deciduous tree), Height: 6-10m, Stem diameter: | Altitude: 1600-2400masl Rainfall: AEZ: dry, Moist and wet woina dega and dega | Propagation method: direct seeding, seedling and cutting; pre-treatment is not necessary | Products: Poison, Fodder, Medicine, |
| | | | | | Tree management: Trimming | Services: Shade or shelter, Ornamental |
| | | | | | Seed management: Seed can be stored; Number of seeds is about 150,000 /kg | |
| 71 | Pinus patula (Exotic) | Amharic: (Patula), English (jelecote pine, Mexican | Family: Pinaceae, Life form: (Tree), Height: 30m, | Altitude: 1000-3000masl, Rainfall: 1000-2000mm AEZ: | Propagation method: Seed, seedling; Pre-sowing treatment is not necessary, seeds germinate within 35-60 days with germination rate of between 75 and 85% | Products: Fuel, Fibre, Timber, Gum or resin, Medicine |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | weeping pine, patula pine, spreading-leaved pine, tecote pine) | Stem diameter: 1-2m | | Tree management: Pruning, thinning | Services: |
| | | | | | Seed management: Seed can be stored; Number of seeds is about 110,000-170,000/kg | |
| 72 | Pinus radiate (Exotic) | Amharic: (Radiata), English (Monterey pine, radiata pine) | Family: Pinaceae, Life form: (Evergreen tree), Height: 50m, Stem diameter: | Altitude: 1000-3000masl Rainfall: AEZ: moist and wet woina dega and dega | Propagation method: Seed, seedling; Needs mycorrhizea | Products: Firewwod, Poles, Posts, Timber, Fibre |
| | | | | | Tree management: Pruning, thinning | Services: Ornamental, Wind break |
| | | | | | Seed management: Seed storage behavior is orthodox; Number of seeds is about 33,000-50,000 /kg | |
| 73 | Podocarpus falcatus (Indigenous) | Amharic: (Zigba) English (East African yellow wood, oteninqua yellow wood, podo) | Family: Podocarpaceae Life form: (evergreen shrub or tree), Height: greater than 25m Stem diameter: Up to 40cm | Altitude: 1550-3000masl Rainfall: 1200-1800mm, Moist and wet woina dega and dega | Propagation method:Seeds, Seedlings; seed germinate in 50-90 days at an average rate of 30% up to 6 months. pre-treatment method would be to soak seeds in saturated salt water for 48 hours with germination rate from 20% to 50%. Slow growing. Hardy once established. | Products: Food, Fibre, Timber, Tannin or Dyestuff, Poison, Medicin |
| | | | | | Tree management: Thinning | Services: Ornamental, Shade or shelter |
| | | | | | Seed management: Seed storage is intermediate; Seed can be stored for up to 2 years.Number of seeds is 2100-2600/kg | |
| 74 | Prunus africana (Indigenous) | Amharic: (tikur inchet) English (red stinkwood, iron wood, bitter almond) | Family: Rosaceae Life form: (evergreen tree) Height: 10-36m Stem diameter: Up to 1m | Altitude: 1500-2300 masl Rainfall: 900-2600 mm AEZ: moist and wet woina dega | Propagation method: Seeds, seedlings, wildings; pre-sowing treatment is not necessarythe fleshy parts should be removed from the fruit; germination takes place within 35-50 days; expected germination rate is 60-80%. | Products: Bee forage, Fuel, Timber, Poison, Medicine |
| | | | | | Tree management: Fairly slow growing. | Services: Erosion control, Shade or shelter, Soil improver, Ornamental |
| | | | | | Seed management: Seed does not store well therefore fresh seed should be used; Number of seeds is about 3400-6000 /kg | |
| 75 | Prunus persica (Exotic) | Amharic: (Kock), English (Peach) | Family: Rosaceae, Life form: (deciduous tree), Height: Up to 6m, Stem diameter: | Altitude: 1700-2400masl Rainfall: AEZ: moist and wet woina dega: | Propagation method: Seeds, seedlings, grafting | Products: Firewood, Food |
| | | | | | Tree management:Pollarding to encourage branching. Pruning before the rainspromotes good fruiting. | Services |
| | | | | | Seed management: | |
| 76 | Psidium guajava (Exotic) | Amharic: (zeituna), English (common guava, guava) | Family: Myrtaceae, Life form: (large shrub, or small evergreen tree), Height: 3-10m, Stem diameter: | Altitude: 1200-2000 masl Rainfall 1000-2000mm AEZ: moist and wet woina dega and kolaIt is drought hardy, growswell with irrigation, but will not grow in waterlogged soils. | Propagation method: Seeds, seedlings, budding, air layering, cutting, grafting; seeds germinate within 15-20 days | Products: Food, Bee forage, Fuel, Timber, Tannin or Dyestuff, Essential oil, Alcohol, Poison, Medicine |
| | | | | | Tree management: Irrigation during the dry season and frequent light pruning, | Services: Ornamental, Boundary or barrier support, Intercropping |
| | | | | | Seed management: Seeds are orthodox; Number of seeds is about 500,000/kg | |
| 77 | Rhamnus prinoides (Indigenous) | Amharic: (Gesho), English (shiny leaf, dog wood, dark blinkblaar) | Family: Rhamnaceae Life form: (Shrub or small tree), Height: Up to 9m, | Altitude: 1000-3200 masl Rainfall: AEZ: moist and wet kola and woina dega and moist dega | Propagation method: Seeds, seedlings, seeds germinate within 2-8 weeks; germination rate is 80-90%. Germinates readily. | Products: Alcohol |
| | | | | | Tree management: Pruning | Services: Erosion control, Shade or shelter |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | | Stem diameter: | | Seed management: seed stores very well; Number of seeds is about 60,000/kg | |
| 78 | Schinus molle (Exotic) | Amharic: (qundo berbere), English (pepper tree, California pepper tree, Chilean pepper tree, mastic tree, molle, pepper berry tree, weeping pepper, Peruvian mastic, pink pepper, Peruvian pepper tree) | Family: Anacardiaceae<br>Life form: (evergreen tree) Height: 3-15m<br>Stem diameter: | Altitude: 0-2400 masl<br>Rainfall: 300-600mm<br>AEZ: bereha, and dry, moist and wet kola, woina dega and dega | Propagation method: Seeds, seedlings, No pre sowing treatment; seeds germinate in 10-30 days; germination rate is 40-80% | Products: Food, Bee forage, Firewood and Charcoal, Timber, Gum and resin,latex or rubber, Dyestuff, Essential oil , Alcohol, Medicine |
| | | | | | Seed management: Seeds storage Seed can be stored; Number of seeds is about 31,000-44,000/kg | Services: Erosion control, Shade or shelter, Ornamental, Boundary or barrier support |
| | | | | | Tree management: Pruning, Coppicing, pollarding and lopping. A fast-growing tree. | |
| 79 | Siamese Senna (Exotic) | | Height: grows up to 18 m | Altitude: 0-1300 masl<br>Rf:500-2800 mm<br>AEZ: Dry, moist and wet Kola | Propagation method: seed, soak seed in nearly boiling waterfor 12-24 hours, Germination % is 90% and germinates in 90 days. Untreated seed germinates 75%. | Product: Food, medicine |
| | | | | | Tree management: tree grows fast and respond well to coppicing | Service: Agroforestry, wind break, shelter, hedgerows, rehabilitation of degraded land, erosion reduction |
| | | | | | Seed management:Storage behaviour is orthodox, Viability can be maintained for 3 years in hermetic storage,there are 35 000-45 000 seeds/kg | |
| 80 | Sesbania sesban (Exotic) | Amharic: (girangire, sesbania), English (common sesban, Egyptian rattle pod, frother, sesbania, sesban, river bean) | Family: Fabaceae – Papilionoideae<br>Life form: (shrub or small tree)<br>Height: 1-7m<br>Stem diameter: | Altitude: 100-2300masl<br>Rainfall: 500-2000mm<br>AEZ: moist and wet kola and woina dega | Propagation method: Seeds, direct sowing, seedlings, Pre sowing treatment is scarification, hot water treatment or soaking in cold or tepid water for 24 hours, seed germination rate is 65% in about 16 days | Products: Fodder, Firewood and charcoal, Fibre, Gum or resin, Poison, Medicine |
| | | | | | Tree management: Coppicing, pruning | Services: Shade or shelter, Soil improver, Intercropping, Boundary or barrier support |
| | | | | | Seed management: Seed can be stored for long periods if kept in a cool and dryplace.; Number of seeds is about 85,000-100,000/kg | |
| 81 | Spathodea nilotica (Exotic) | Amharic: (Spathodea), English (African tulip tree, flame of the forest, fountain tree, Nandi flame, Nile flame, squirt tree, tulip tree, Uganda flame) | Family: Bignoniaceae,<br>Life form: (tree),<br>Height: 10-35m,<br>Stem diameter: | Altitude: 0-2000masl,<br>Rainfall: 1300-2000mm<br>AEZ: Bereha, and moist and wet kolla and woina dega | Propagation method: Seeds, seedlings, cuttings and root suckers. Seed treatment not necessary. Good seed germination rate. | Products: Food, Timber, Medicine, Poison |
| | | | | | Tree management: Fairly fast growing.Coppicing | Services: Shade or shelter, Reclamation, Ornamental |
| | | | | | Seed management: Seed does not store well; it should be sown fresh.; Number of seeds is about 150,000/kg | |
| 82 | Syzygium guineense (Indigenous) | Amharic: (Dokma) English (waterpear, waterboom, water berry, snake bean | Family: Myrtaceae<br>Life form: (medium-sized or tall evergreen tree)<br>Height: 15-30m | Altitude: 0-2100 masl<br>Rainfall: 1000-2300mm<br>AEZ: moist and wet kola and woina dega | Propagation method: Seeds, direct sowing,seedlings, wildlings, coppice, Seed needs no pre-sowing treatment, germination rate is 80-90% are attained after 20 to 50 days | Products: Food, Bee forage, Timber, Poison, Medicine, Firewood and charcoal |
| | | | | | Tree management: Coppicing, pollarding | Services: Shade or shelter |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | tree, woodland waterberry, mountain waterberry, bi-coloured waterberry) | Stem diameter: | | Seed management: Seed management: Seed does not store well; it should be sown immediatelyfreshSeeds may be spoilt in less than 24 hours; Number of seeds is about 2400-3700/kg | |
| 83 | Terminalia brownie (Indigenous) | Amha:Abolo, Weyeba Eng:Browns's myrobalan | Family: Combretaceae Height: 7-13 | Altitude: 300–2,000 m. AEZ: Dry, Moist and Wet Kolla and Weyna Dega | Propagation method: seed, wildings. Prolific seeder, but a low germination rate.. Treatment: Remove wings and soak in cold water overnight. | Products: Fire wood, Charcoal, timber, fodder |
| | | | | | Tree management: Fairly fast growing on good sites. Lopping, pollarding, coppicing | Services: soil improvement, mulch, shade |
| | | | | | Seed management: Seed can be stored for very long periods if insect free. About 3,000 seed per kg | |
| 84 | Trichilia dregeana (Indigenous) | Amharic: *Bonga* | Height up to 30 m | Altitude: 1,400--2,200 m. AEZ: Moist and Wet Weyna Dega | Propagation method : seed, No pre-treatment is required, but removal of the fleshy outer seedcoat speeds up germination , seed usually sprouts within 2 - 4 weeks | Product: Firewood, timber (construction, furniture), food, medicin |
| | | | | | | Service: Shade. |
| | | | | | Seed management:has a short viability, so should be sown as soon as it is ripe | |
| 85 | Vernonia amygdalina (Indigenous) | Amharic: (Girawa), English (vernonia tree, bitter leaf ) | Family: Asteraceae, Life form: (bushy shrub or well-formed tree ), Height: Up to 7m, Stem diameter: | Altitude: 600-2800masl , Rainfall: 750-2000 mm, AEZ: moist and wet kola, woina dega and dega | Propagation method: Seedlings, direct sowing, cuttings | Products: Fodder, Fuel wood, Bee forage, Timber, Medicine |
| | | | | | Tree management: Coppicing | Shade or shelter Services: Essential oil, Boundary or barrier support, Ornamental |
| 86 | Ximenia Americana (Indgenous) | Amharic: (Enkoy, Kol), English (plum, wild plum, false sandalwood, seaside plum, small sourplum, sour plum, tallow nut, tallow wood, wild lime, wild olive) | Family: Olacaceae, Life form: ( bush-forming shrub or small tree), Height: 2-7m, Stem diameter: Up to 10cm | Altitude: 900-2500 masl, Rinfall: 300-1250 mm, AEZ: dry, moist and wet kola, woina dega and Dega | Propagation method: Seeds, seedlings, coppicing, cutting | Products: Food, Firewood and charcoal, Tannin or Dyestuff, Lipids, Essential oil, Alcohol, Poison, Medicine |
| | | | | | Tree management: Coppicing, trimming | |
| | | | | | Seed management: Seed management: Seed storage:Seed cannot be stored for long periods. Sow fresh seed forgood germination.; Number of seeds is about 1400/kg | Services: Ornamental, Boundary or barrier support |
| 87 | Ziziphus mauritiana (Indigenous) | Amharic: (Kurkura, gaba) , English (bear tree, ber, Chinese apple, Chinese date, common jujube, desert apple, dunks, geb, Indian cherry, | Family: Rhamnaceae Life form: (spiny, evergreen shrub or small tree ) Height: Up to 15 m Height: Up to 15 m | Altitude: 400-1600masl Rainfall: 120-2200mm AEZ: dry and moist kolla | Propagation method: seedling, direct sowing, cutting, root suckers; pre-treatment can be mechanical scarification, sulphuric acid treatmentor Soak in cold water, crack hard seed cover.Germination rates often low. | Products: Food, Fuel wood, Bee forage, Timber, Medicine |
| | | | | | Tree management: Lopping, pollarding, pruning | Services: Erosion control, Reclamation, Ornamental, Boundary or barrier support |
| | | | | | Seed management: Seed management: Seed can be stored up to a year.Number of seeds is about 430-2000/kg | |

| S/N | Scientific name | Local name | Description | Ecology and distribution | Propagation and management | Uses |
|---|---|---|---|---|---|---|
| | | Indian jujube, Indian plum, jujube) | | | | |
| 88 | Ziziphus mucronata (Indigenous) | Amharic: (foch, ado kurkura), English (buffalo thorn, Cape thorn) | Family: Rhamnaceae, Life form: (shrub or medium-sized tree), Height: Up to 9m, Stem diameter: | Altitude: 100- 2100 masl Rainfall: 440-1200mm, AEZ: Bereha and Dry, Moist and Wet Kolla and WeynaDega. | Propagation method: Seeds, seedlings, root suckers, pre-sowing treatment is remove the flesh and soak in cold water for 6 hours, germination rate is about 75% within 2-3 weeks | Products: Food, Fodder, Bee forage, Firewood and charcoal, Timber, Tannin or Dyestuff, Medicine |
| | | | | | Tree management: Coppicing, trimming | Services: Boundary or barrier support |
| | | | | | Seed management: Seed management: Seed storage behaviour is orthodox; Number of seeds is about 500-2000/kg | |
| 89 | Ziziphus spina-christi (Indigenous) | Amharic: (kurkura), English () | Family: Rhamnaceae, Life form: (a shrub, sometimes a tall tree), Height: Up to 20m, Stem diameter: up to 60cm | Altitude: 0-1900masl Rainfall: AEZ: Bereha and dry and moist kolla | Propagation method: Seedlings and cuttings; seed pre-treatment is cracking the hard seed coat and the seeds soaked in warm water overnight; germination rate is 60-80 % and seedlings reach maturity in 4-5 months | Products: Firewood and charcoal, Timber, Food, Fodder, Medicine |
| | | | | | Tree management: Coppicing, lopping pollarding | Services: Shade or shelter, Live fence, Erosion control, Soil improver, Intercropping |
| | | | | | Seed management: Seed stores well; Number of seeds is about 15,000/kg | |
| 90 | *Atriplex nummularia* | English: Salt bush | Family: , Height: Up to 10m, Stem diameter: | Altitude: Grows on all elevation ranges Rainfall: 50-500 mm AEZ: Kolla, Weinadega and Dega | Propagation method: Saltbush is propagated by seed. Propagation by seed is usually done by sowing the fruiting bracteoles. | Products: Fodder, Firewood |
| | | | | | Tree management: It is advisable to prune the plants every 4-5 years, by cutting-down woody branches at 25 cm above the soil level. | Services: Shade or shelter, Live fence, Saline area rehabilitation, Soil conservation, Ornamental , |
| | | | | | Seed management: Recent study made shows that seeds of salt bush exhibits exogenous and endogenous dormancy (>90%). This can be broken by keeping the seed for one year. Old seeds (one year old), germinated better than freshly harvested seeds. | |
| 90 | *Cajanus cajan* | Amharic English: Pigeon pea | Family:*Fabaceae* , Height: Up to 4m, Stem diameter: | Altitude: 0- 3000 masl Rainfall: 250-1000 mm AEZ: Kolla, Weinadega and Dega | Propagation method: Pigeon pea is propagated by seed. Seed is sown at a distance of 30-50 cm by placing one-two seeds at each spot at a depth of 5-10 cm. This requires 0.5-0.75 kg/km. For pure stand, seeding rate is 4 kg /ha. | Products: Food, Fodder, Fuel wood |
| | | | | | Tree management: Pigeon pea can stay up to 5 years. After harvest in the first year the plants are cut 30-50 cm above the ground. Pruning is done yearly during the rainy season after harvest. | Services: Soil improvement, Soil conservation |

*Annex 3. List of grass species and legumes, suitable environment, propagation methods and their uses*

| No | Name of planting material | Suitable areas | Propagation and Establishment | Planting location and use |
|---|---|---|---|---|
| 1 | Elephant grass (*Pennisetum purpureum*) | Altitude: Below 2100 masl. At higher altitudes (above 2100 m), growth is slowed by lower temperature.<br><br>Rainfall. Requires >1000 mm, although it is extremely drought tolerant because of its deep root system; It grass can survive 6-8 months of drought. However, in the establishment phase it needs sufficient moisture. | Either splits (root splits) or stem cuttings are used for propagation. Usually by stem cuttings buried in furrows, 2 nodes in soil and one exposed. One ha of grass provides planting material for 15–20 ha. Cuttings/splits are planted 0.25- 0.5 m apart. Distance between rows is 0.4-1 m. Close spacing is required for soil conservation contour hedgerows and for high rainfall environments. More open spacing is used in drier environments. Needs moisture during planting and establishment. Elephant grass can survive 6-8 months of drought once established. | It is mainly planted along gully walls and in degraded grazing areas. Its main use is conservation (Stabilization of degraded areas) and Fodder. |
| 2 | Bana grass (Pennisetum purpureum xP.typhoides) | Same as elephant grass | It is propagated by cutting from matured canes or by root splits. Cuttings/splits are planted 0.25- 0.5 m apart. . Distance between rows is 0.4-1 m. Once established, it is drought tolerant and hardy. | Planted on lower part of gully walls, along soil bunds or fanya-juu and on range lands. Its main use is conservation (Stabilization of degraded areas) and Fodder. |
| 3 | Green Gold (Pennisetum spp.) | Same as elephant grass | It is propagated by cutting from matured canes or by root splits. Cuttings/splits are planted 0.25- 0.5 m apart. . | It is mainly planted on lower parts of the gully and Gully beds. It needs moist condition for best performance but will also do under somewhat drier condition. It can stand water logging.<br>Its main use is conservation (Stabilization of degraded areas) and Fodder. |
| 4 | Vetiver (*Vetiveria zizanioidesis*) | Altitude: Can be grown successfully from sea level up to 3000 m.a.s.l.<br>Rain fall:Vetiver has been found to thrive under rainfall ranging from 300 mm to 6000 mm per annum. It can survive total drought. It tolerates flood and submergence and can survive complete submergence in water for up to three months. Vetiver ionly s sensitive to shade and this will slow growth, especially in young plants. | Vetiver rarely produces seed and is multiplied vegetatively using tillers (shoots growing from the base of the stem of the plant) or using a clump (bunch of tillers). 3-4 tillers are per station along the structure or the contour at an interval of 10 cm. | Vetiver is planted along the contour, soil bunds, Fanya-juu, across water ways, on boundary of water harvesting structures, gully buds, gully offset and e.tc. Its main use is conservation (Stabilization of degraded areas) and Fodder. |
| 6 | Desho grass (Pennisetum pedecillatum) | Altitude:Desho grass can grow at 1500-2800 m.a.s.l and its best performs at an altitude of 1700-2800 masl | Desho grass can be established by seed and splits (tillered cuttings). One clump can splitted to 20 to 30 seedlings (splits). Propagating by splits have high survival rates and establishes better than grasses which are seeded. It is established easily with little soil moisture. | Splits of desho grass (Pennisetum pedecillatum) are planted in lines, using a hand hoe, after good seedbed preparation Spacing between grass splits is 10 x 10 cm. It is mainly planted along soil bunds and Fanya-juu and grazing areas. It is also planted on boundary of water harvesting structures. For degraded grazing land, the recommended spacing is 50 cm by 50 cm intervals.<br>Its main use is conservation (Stabilization of degraded areas) and Fodder. |

| No | Name of planting material | Suitable areas | Propagation and Establishment | Planting location and use |
|---|---|---|---|---|
| 7 | Chemo grass (Brachiaria humidicola) | Altitude:1000-2400 m.a.s.l<br>Rainfall:In its native place, annual rainfall varies from 600–2800 mm, but less vigorous in environments with <1600 mm annual rainfall and more than 6 months dry season. Grows best in full sunlight but has moderate shade-tolerance. Chemo grass is better adapted to longer dry season. | It is usually established vegetatively, It establishes reliably and spreads rapidly from stem cuttings planted at 1 m -2 m spacing.<br>It is also propagated by seed. Seed may be dormant for 6 months after harvest and so should be stored or acid-scarified before planting. Seed is broadcast at 2–8 kg/ha (depending on germination percentage). Seed will decline in quality rapidly if stored inappropriately and poor seed quality has been the cause of many planting failures.<br>It must be stored in low temperature and low humidity conditions to prevent seed quality decline, which can be severe.<br>There is very limited flowering and seed production at low latitudes. | It is best suited to degraded and termite infested areas. However, it is not suitable to stabilize soil bunds in crop fields because of its invasive feature.<br><br>Its main use is conservation (Stabilization of degraded areas) and Fodder. Readily eaten by cattle when kept short and leafy. Palatability can be low if grown on acid infertile soils. |
| 8 | Rhodes grass (Chloris gayana) | Altitude: 600-2200 m.a.sl<br>Rainfall: 650-1200 mm | *Chloris gayana* can be vegetatively propagated or established from seeds. For vegetative propagation, larger clumps can be cut into pieces and planted at 1 m distance from each other. When propagated by seed, seed rate is 5-7 kg/ha. | It is planted or sown on degraded grazing areas and gully beds. Rhodes grass readily establishes and provides cover within 3 months of sowing. Its creeping habit provides good soil stabilization and, is commonly used for the revegetation of degraded and areas disturbed soils. It has vigorous root system and is drought tolerant. Besides, Rhodes grass is used for forage. It is a forage of high quality. |
| 9 | Phalaris (Phalaris aquatic) | Altitude: 1200-3000 m.a.s.l<br>Rainfall:It requires 500 mm annual rainfall with good distribution from autumn to spring for optimal growth. However, it can grow in places where annual rainfall is as low as 300 mm provided the soil has good moisture holding capacity. | It propagated by vegetative means (splits) and seed. | It good for gully bed, soil bund stabilization, Trench bund stabilization bank stabilization and excellent for rehabilitation of water ways. |
| 10 | Vetch (*Vicia dasycarpa* L.) | Altitude: 1500-3000 m.a.s.l<br>Rainfall: It can grow on wide rainfall range, However, it can grow in places where annual rainfall is as low as 400 mm. | It is propagated by seed at the rate of: 20 kg/ha (pure stand); 12 kg/ha (under sown); 5-12 kg/ha (pioneer component of pasture mix); 12-20 kg/ha (sown with oats).Companion species: Oats (Avena sativa). | It is mainly grown on farmland for cover cropping and green manuring. It is also a valuable source of animal feed. |
| 11 | Brachiaria spp. Hybrids (Cultivar Mulato ) | Altitude: Does not occur naturally. It is an Artificial hybrids and is suited to low altitudes from sea level up to 1,800 m.a.s.l.<br>Rainfall: Adapted to annual rainfall of 1000-3500 mm. 1,000 - 3,500 mm/year, including areas with a dry season of 5 - 6 months. Experience shows that these hybrids may be useful in areas with annual rainfall as low as 700 mm. | Cv. Mulato can be planted from seed planted into a well-prepared seedbed at 4–6 kg/ha seed. Can be planted vegetatively from stolon cuttings. Establishes rapidly, achieving 85% ground cover at 2 months after seeding. Can be lightly grazed after 3–4 months.<br>It is initially established by Seed, subsequently vegetative. | It can be grown in hilly and terraced areas which are characterized by high acidity and high aluminium contented Mulato is reported to be highly palatable to grazing ruminants.<br>It extremely productive and has high nutritive value. |

| No | Name of planting material | Suitable areas | Propagation and Establishment | Planting location and use |
|---|---|---|---|---|
| 12 | Lablab (Dolichos lablab) | Rainfall requirement: 500-1500<br>Altitudes: From sea level to elevations of up to 2,000 masl in tropical environments | It is propagated by seed Seeds are sown drilled at 1-2cm depth after rough seedbed preparation, with seed rate 6 kg/ha in mixture with grass and 15-20<br>kg/ha as sole legume. | Good as cover crop and for improved fallows, ley cropping, green manuring with fodder crops (sorghum, millet) and few grass. Good as grazed fodder crop.<br><br>As good as, and even better than, cowpea (Vigna sinensis) for green manuring and as a pioneer pasture legume |
| 13 | Panicum or Guinea grass (Panicum maximum) | Altitude: 0-2500 meters above sea level<br>Rainfall: 800-1000 mm | It is propagated by seed. Seed is drilled or broadcasted at 2-3 kg/ha and should be planted at no more than 1 cm deep. It can also be established from rooted tillers (or cuttings with thick stemmed varieties) planted on the contour every 0.5-0.6 m in rows 1.25-1.5 m apart, or as close as 40 cm in a triangular pattern if a faster cover is required. | Guinea grass grow vigorously and are ideal for their soil-binding properties. The deep, dense and fibrous root system allows guinea grass to survive quite long drought periods They are also good sources of fodder for livestock. It can planted along the contour lines or on soil bunds, fanya-juu and pasture areas |
| 14 | Star grass (*Cynodon plectostachyus)* | Altitude: 800-2000 m.a.s.l<br>Rainfall: 500-1500 m.a.s.l | *Star grass* is propagated by planting freshly harvested stem cuttings (1 cutting/m²) at the beginning of the rainy season on a firm seed bed. | Star grass can be sown to protect soils against superficial erosion and in pasture areas |
| 15 | Desmanthus virgatus | Altitude: sea level to 1,900 m<br>Rainfall: 550-1,000 mm | It is propagated by seed. Fresh seed is extremely hard and should be scarified. Sow 2 kg/ha of scarified seed at a depth of 0.5-2.0 cm into moist soil with at least 50-60 cm depth of good moist soil to ensure establishment. | Use for alley cropping and green manuring and re-vegetation of grazing areas |
| 16 | Guatemala grass (Tripsacum andersonii) | Altitude: sea level up to 1800 m<br>Rainfall: Requires reliable rain or soil moisture . | Guatemala grass is usually propagated from stem cuttings or rooted culms at the beginning of the rainy season. Stem cuttings with 3 nodes or rooted culms or rhizomes (800–3,000 kg/ha) at spacings of 0.5 m x 1 m. Can be cut 4–6 months after planting. | Guatemala grass is used for hedges or for contour stripping of crops planted on steep slopes. Guatemala grass is a good soil binder and organic matter builder. In the highlands of East and Central Africa, it is used to combat soil erosion and increase the stability of contour bunds. Guatemala grass is more effective when combined with companion trees such as *Sesbania*, *Gravillea* or *Desmodium*. |
| 17 | Greenleaf desmodium (*Desmodium intortum)* | Altitude: It does better at altitudes between 500 and 2500 m in the tropics.<br>Rainfall: It can be grown in areas where annual rainfall is above 900 mm and up to 3000 mm. | Propagation: Greenleaf desmodium is propagated by seed. Once established, It is also possible to propagate Greenleaf desmodium by rooted cuttings. Once established, Greenleaf desmodium grows vigorously and spreads rapidly because of its solons. It has very small seeds and requires a well prepared seedbed for establishment. | Being an N-fixing legume, green leaf desmodium can improve soil fertility. It can be used as ground cover as it needs only 4 months to cover the soil. |

*Annex 4. Selected tree species for different land uses*

| Trees for rehabilitation of degraded /communal areas | Homestead/Backyard | Agroforestry (Farmland) | Woodlot |
|---|---|---|---|
| *Accacia abysinica* | *Acacia nilotica* | *Acacia abysinica* | *Acacia decurrense* |
| *Acacia melanoxylon* | *Acacia tortilis* | *Acacia bussei* | *Olea africana* |
| *Acacia brevispica* | *Albizia gummifera* | *Acacia etbaica* | *Acacia meamsii* |
| *Acacia polyacantha* | *Annona muricata* | *Acacia lahai* | *Hagenia abyssinica* |
| *Acacia saligna* | *Annona senegalensis* | *Acacia senegal* | *Pinus patula* |
| *Acacia seyal* | *Azadiarachta indica* | *Acacia sieeriana* | *Podocarpus falcatus* |
| *Acacia tortilis* | *Arundinaria alpine* | *Acacia tortilis* | *Syzygium guineense* |
| *Albizia lebbeck* | *Carica papaya* | *Acacia seyal* | *Accacia abysinica* |
| *Albizia gummifera* | *Casuarina equisetifolia* | *Albizia gummifera* | *Acacia albida* |
| *Albizia schimperiana* | *Citurs spp* | *Azadirachta indica* | *Acacia seyal* |
| *Azadirachta indica* | *Coffee arabica* | *Balanites aegyptica* | *Acacia etbaica* |
| *Balanites aegyptica* | *Cordia africana* | *Carica papaya* | *Acacia. bussei* |
| *Cajanus cajan* | *Casmiroa edulis* | *Cassia siamea* | *Balanites aegyptica* |
| *Cassia siamea* | *Cupressus lusitanica* | *Cajanus cajan* | |
| *Casuarina cunninghamnia* | *Enset ventricosum* | *Chamaecytisus palmensis* | |
| *Casuarina equisetifolia* | *Erythrina brucei* | *Cofea arabica* | |
| *Croton macrostachyus* | *Gravillea robusta* | *Croton macrostachyus* | |
| *Delonix regia* | *Hagenia abyssinica* | *Faidherbia albida* | |
| *Dodonaea angustifolia* | *Mangifera indica* | *Mangifera indica* | |
| *Dombeya torrida* | *Moringa oleifera* | *Millettia ferruginea* | |
| *Erythrina abyssinica* | *Moringa stenoptala* | *Persea Americana* | |
| *Grevillea robusta* | *Opuntia ficus indica* | *Prosopis cineraria* | |
| *Juniperus procera* | *Persea Americana* | *Tamarindus indica* | |
| *Morus alba* | *Psidium guajava* | *Ziziphus spina-christi* | |
| *Perkinsonia aculeata* | *Rhamnus prinoides* | | |
| *Leucaena leucocephala* | *Schinus molle* | | |
| *Ricinus communis* | *Tamarindus indica* | | |
| *Schinus molle* | *Vernonia amygdalina* | | |
| *Tamarindus indica* | | | |
| *Ziziphus spina-christi* | | | |
| *Atriplex nummularia* | | | |

*Annex 5. Recommended Plant Species for Biological Gully Rehabilitation, Rangeland Improvement and Field bunds. HL = Highlands LL= Lowlands*

| Planting Location | Category | Species | Remarks |
|---|---|---|---|
| Gully Floor or Gully Bed | Covering grasses | Kikuyu grass (Pennisetum clandestinum) | Highlands (HL), lowlands (LL) |
| | | Riverine Kikuyu (Pennisetum riparium) | Needs high moisture, HL,LL |
| | | *New grass from Fogera* | Needs high moisture, LL |
| | | Bermuda grass (Cynodon dactylon) | Especially in sandy soils, HL,LL |
| | Covering legumes | Birds foot trefoil (Lotus corniculatus) | Propagation: stem layering, splitting, HL,LL |
| | Other legumes | Sunhemp (Crotalaria juncea) | |
| | | Fish bean (Tephrosia vogelii) | Drought hardy, HL, LL |
| | Tall grasses | *Shambokko* or Spanish reed (Arundo donax) | HL, LL |
| | | *Kerkeha* or Mountain bamboo (Arundinaria alpina) | HL |
| | | Common reed (Phragmites communis) | HL, LL |
| | Tall grasses (continued) | Phalaris (Phalaris aquatica, P. arundinacea) | HL, LL |
| | | Tall fescue (Festuca arundinacea) | Drought hardy, HL, LL |
| | | Vetiver (Vetiveria zizanioides) | For hedgerows across the gully bed, HL, LL |
| | | Green gold (Pennisetum spp.) | Can stand water-logging, HL, LL |
| | Trees | Hybrid poplars | HL, LL |
| | | Grey poplar (Populus canescens) | Can have colonizing effect in gully beds, HL, LL |
| | | *Ahaya or Wild willow* (Salix subserrata) | Moist conditions, HL, LL |
| | | Basket willow (Salix viminalis) | Needs moist conditions, HL, LL |
| | | Erect weeping willow (Salix babylonica) | Needs moist conditions, HL, LL |
| | | Stink bean (Paraserianthes lophantha) | Drought hardy, HL, LL, fast growing |
| | | Sesbania (Sesbania sesban) | HL, LL |
| | Trees | Tamarisk (Tamarix aphylla, T. nilotica) | In dry or waterlogged areas, tolerates salt, better in LL |
| | | Dokma or Waterberry (Syzygium guineense) | In dry, lower altitudes |
| Gully walls | Tall grasses | *Shambokko* or Spanish reed (Arundo donax) | HL, LL |
| | | *Kerkeha* or Mountain bamboo (Arundinaria alpina) | HL |
| | | Vetiver (Vetiveria zizanioides) | For hedgerows along sidewalls, HL, LL |
| | | *Shenkora Ageda* or Sugar cane (Saccharum sp.) | Lower parts of sidewalls, LL |
| | Fodder grasses | Green gold (Pennisetum spp) | Lower parts of sidewalls and gully bed, needs moist conditions for best performance but will also do under somewhat drier conditions, HL, LL |
| | | Bana grass (Pennisetum purpureum x P. typhoides) | Lower parts of sidewalls, rangeland, drought hardy, needs feeding (manure, fertilizer) HL, LL |
| | | Elephant grass (Pennisetum purpureum) | Lower parts of sidewalls, in rangeland, needs feeding (manure, fertilizer), HL, LL |
| | Fodder grasses (continued) | *Senbelet* (Hyparrhenia nyassae) | Lower and upper parts of sidewalls, HL,LL |
| | | Weeping love grass (Eragrostis curvula) | Upper parts of sidewalls, on sandy soils, very drought resistant, HL, LL |
| | Annual grasses | *Teff* (Eragrostis teff) | HL, LL |
| | | *Dagusa* (Eleusine corolana) | |
| Gully walls | Covering legumes | Kudzu (Pueraria thunbergiana) | Lower parts of sidewalls |
| | | Crown vetch (Coronilla varia) | Lower and upper parts of sidewalls, very drought resistant, no waterlogging, HL, LL |
| | Other legumes | Pink and Yellow serradella (Ornithopus sp.) | Lower parts of sidewalls, HL, LL |
| | | Lespedeza (Lespedeza sericea) | Dry conditions only, LL |
| | Trees/Shrubs | Green wattle (Acacia decurrens) | HL, LL |
| | | Silver wattle (A. dealbata) | HL, LL |
| | | Blackwood (Acacia melanoxylon) | Especially lower parts of sidewalls, HL, LL |
| | | Saligna or Port Jackson willow (Acacia saligna) | HL, LL |

| Planting Location | Category | Species | Remarks |
|---|---|---|---|
| | | Prairie wattle (Acacia angustissima) | Lower parts of sidewalls, drought hardy, HL, LL |
| | | *Kitkita* or Hop bush (Dodonaea angustifolia | HL, LL |
| | | *Enset* or False banana (Enset ventricosum) | Lower parts of sidewalls, HL, LL |
| | | *Shola* or Fig tree (Ficus carica) | Lower parts of sidewalls HL, LL |
| | Trees/ shrubs | Elderberry (Sambucus nigra) | HL |
| | | Leucaena (Leucaena leucocephala, L. pallida) | LL |
| | Trees/ shrubs (continued) | Sturt's pea (Cassia sturtii) | Very drought hardy, LL |
| | | Calliandra (Calliandra calothyrsus) | Not doing well in HL |
| | | Sesbania (Sesbania sesban) | HL, LL |
| | | Mulberry (Morus nigra, M. alba) | Lower part of sidewalls, HL, LL |
| | | *Shiferaw* (Moringa oleifera, M. stenopetala) | Lower part of sidewalls, at low altitudes, LL |
| | | Pigeon pea (Cajanus cajan) | Lower part of sidewalls, at lower altitudes, not for HL |
| | | Teline (Teline canariensis, T. monspessulanus, T. maderensis) | Drought hardy, no waterlogging, HL, LL |
| | Live fences, along sidewalls | Sisal (Agave sisalana, A. americana) | Mainly upper parts of sidewalls, Live Fence, HL, LL |
| | | Aloe (Aloe africana, A. vera) | Dry areas, HL, LL |
| Gully offsets and Rangelands | Grasses | *Senbelet* (Hyparrhenia nyassae) | Very drought resistant, grows also on very poor soils, HL, LL |
| | Trees/ shrubs | Saligna or Port Jackson willow (Acacia saligna) | HL, LL |
| | | Silky oak (Grevillea robusta) | HL, LL |
| | | Sesbania (Sesbania sesban) | Drought hardy and can stand wet conditions, HL, LL |
| | | Casuarina (Casuarina equisetifolia) | Drought hardy, HL, LL |
| | | Blackwood (Acacia melanoxylon) | HL, LL |
| | | Prairie wattle (Acacia angustissima) | Lower parts of sidewalls, drought hardy, HL, LL |
| | | *Bisana* (Croton macrostachyus) | |
| | Trees/ shrubs (continued) | *Sesa* (Albizia schimperiana) | |
| | | *Wanza* (Cordia africana) | HL,LL |
| | | *Serk Ababa* (Cassia siamea) | Invading species, HL,LL |
| | | Saltbush (Atriplex nummularia) | Very drought resistant, no waterlogging, HL, LL |
| | | Teline (Teline canariensis, T. monspessulanus, T. maderensis) | Very drought resistant, no waterlogging, HL, LL |
| | Live fences along outer edge of offsets | Tree lupin (Lupinus arboreus) | Drought hardy, HL, LL |
| | | *Bazra girar* (Acacia abyssinica) | HL,LL |
| | | *Kontir* (Acacia mellifera) | HL,LL |
| | | *Grar* (Acacia albida) | LL |
| | | *Cheba* (Acacia nilotica) | Very drought resistant, HL, LL |
| | | Agave (Agave sisalana) | Very drought resistant, HL, LL |
| | | Aloe (Aloe africana) | Dry areas only, HL, LL |
| | | *Kulkual* (Opuntia ficus-indica) | Dry areas only, HL, LL |
| Field bunds | Grasses | Vetiver (Vetiveria zizanioides) | Very drought resistant, HL, LL |
| | | Phalaris (Phalaris aquatica) | Needs moist conditions, HL, LL |
| | Fodder strips | Bana grass (Pennisetum purpureum x P. typhoides) | Drought hardy, HL, LL |
| | | Alfalfa (Medicago sativa) | Drought hardy, HL, LL |

*Annex 6. Seed sowing period for different species*

| No. | Type of species | Seed sowing period | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | J | F | M | A | M | J | J | A | S | O | N | D |
| 1 | Acacia abyssinica | * | | | | | | | | | | | |
| 2 | Acacia albida | | * | * | | | | | | | | | |
| 3 | Acacia decurrens | * | * | * | | | | | | | | | |
| 4 | Acacia lahai | * | * | | | | | | | | | | * |
| 5 | Acacia nilotica | * | * | | | | | | | | | | |
| 6 | Acacia raddiana | * | * | | | | | | | | | | |
| 7 | Acacia Saligna | | | * | * | | | | | | | | |
| 8 | Acacia Senegal | | * | * | | | | | | | | | |
| 9 | Acacia Seyal | | | * | * | | | | | | | | |
| 10 | Acacia Sieberiana | * | | | | | | | | | | | |
| 11 | Agave americana | | | | | | | | * | * | | | |
| 12 | Agave Sisalana | | | | | | | | * | * | | | |
| 13 | Albizia lebbeck | * | * | * | | | | | | | | | |
| 14 | Azadirachta indica | * | | | | | | | | | | | |
| 15 | Balantis aegyptiaca | * | * | | | | | | | | | | |
| 16 | Cajanus Cajan | * | | | | | | | | | | | * |
| 17 | Carica Papaya | | * | * | | | | | | | | | |
| 18 | Casuarina Cunninghamina | | | | | | | | | * | * | | |
| 19 | Casuarina equistifolia | | | | | | | | | | | | * |
| 20 | Citrus Sinensis | | | | | | | | | * | * | * | |
| 21 | Cordia Africana | * | * | | | | | | | | | | |
| 22 | Croton macrostachys | * | * | * | | | | | | | | | |
| 23 | Cupressus Lusitanica | | | | | | | | | * | * | | |
| 24 | Delonix Regia | | * | * | | | | | | | | | |
| 25 | Eucalyptus Camaldunesis | * | * | | | | | | | | | | |
| 26 | Eucalyptus Citriodora | * | * | | | | | | | | | | |
| 27 | Eucalyptus globulus | * | * | | | | | | | | | | |
| 28 | Eucalyptus saligna | | * | * | | | | | | | | | |
| 29 | Eucalyptus tereticornis | * | * | | | | | | | | | | |
| 30 | Grevilla robusta | | | | | | | | | | | * | * |
| 31 | Jacaranda mimosifolia | * | * | | | | | | | | | | |
| 32 | Juniperus procera | | | | | | | * | * | * | | | |
| 33 | Leucaena leucocephala | | * | * | | | | | | | | | |
| 34 | Mangifera indica | | | | | | | | * | * | * | | |
| 35 | Mellia azedarach | * | * | | | | | | | | | * | * |
| 36 | Olea africana | | | | | | | | | * | * | * | |
| 37 | Parkinsonia acculata | | * | * | | | | | | | | | |
| 38 | Phoenix reclinata | | | | | | | | | | | * | * |
| 39 | Pinus patula | | | | | | | | | * | * | | |
| 40 | Pinus radiata | | | | | | | | | | | * | * |
| 41 | Podocarpus gracillor | | | | * | * | | | | | | | |
| 42 | Prosopis juliflora | | * | * | | | | | | | | | |
| 43 | Psidium guajava | * | * | | | | | | | | | | * |
| 44 | Rhamnus prinoides | | | | | | | | | | * | * | |
| 45 | Schinus molle | * | * | | | | | | | | | | |
| 46 | Sesbania sesban | | * | * | | | | | | | | | |
| 47 | Ziziphus mauritania | | * | * | | | | | | | | | |
| 48 | Ziziphus spina-Christi | | | * | * | | | | | | | | |

*Annex 7. Nursery work calendar*

| | **Type of activity** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | General activity | | | | | | | | | | | | |
| 2 | Plowing | | | | | | | | | | | | |
| 3 | Bed preparation | | | | | | | | | | | | |
| 4 | Soil transport | | | | | | | | | | | | |
| 5 | Soil sieving | | | | | | | | | | | | |
| 6 | Seed collection | | | | | | | | | | | | |
| 7 | Pot filling | | | | | | | | | | | | |
| 8 | Compost preparation | | | | | | | | | | | | |
| 9 | Grass collection | | | | | | | | | | | | |
| 10 | Seed sowing | | | | | | | | | | | | |
| 11 | Watering | | | | | | | | | | | | |
| 12 | Shade preparation | | | | | | | | | | | | |
| 13 | Erecting shade | | | | | | | | | | | | |
| 14 | Thinning and weeding | | | | | | | | | | | | |
| 15 | Protection from pests | | | | | | | | | | | | |
| 16 | Pruning | | | | | | | | | | | | |
| 17 | Lopping and pruning of grown trees | | | | | | | | | | | | |
| 18 | Grading | | | | | | | | | | | | |
| 19 | Hardening off | | | | | | | | | | | | |
| 20 | Seedling selection | | | | | | | | | | | | |
| 21 | Seedling distribution | | | | | | | | | | | | |
| 22 | Seedling transport | | | | | | | | | | | | |

## *Annex 8. Framework statue for self-help group formation in private nurseries*

Woreda _____

Kebele and/or Watershed _____

Group Name _____

Date Regulations Established_____

Date Revolving Fund Legalized_____

Meeting day _____

Registration Fee _____

Monthly Saving_____

Special Payment per annum_____

Logo_____

***Objective of the Revolving Fund***

Organize jobless women (75%) and youth (25%) surrounding the nursery site and enable them establish or strengthen income generating nursery activities;
Make possible borrow inputs in kind and payback in the same way or cash;
To enable nurseries produce adequate quality seedlings for market;
This objective can only be reached when all members work together, create and be abided by regulations, ensure regular payment of membership fees and repay loans (one hundred percent) within the set time frame;
To become a legalized institution with the right to accuse or be accused in the court of law.
Empower jobless women and use access credit through micro-credit schemes;
Support the jobless form capital and/or seed money upon graduation and get transformed to the next higher business for the new comers to get in nursery trade anew;
Other Objectives:

# 12 CONSTITUTION

## Membership of the Revolving Fund

- Jobless women and youth whose interest is to get organized
- Minimum age limit should be 18 years or above
- Residing within watershed surrounding the nursery site
- Active participant in community works
- Interested to revolve inputs for it to reach all farmers through time
- Willing to practice SWC physical and biological works including homestead development
- Number of the group members could be 20-25 measuring the holding capacity of the allotted land
- Other Requirements;

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## Members' Rights and Obligations

Every member has equal rights. He has the right to speak and vote; the right to elect or be elected as a Management Committee member; the right to accuse or obligation to be accused.

- At the time of graduation and reaching self-supportive stage, self-help group and their respective members are obliged to transfer seed money they have been getting during the project years to newly established group.
- Every member has access to services rendered and benefits generated by the revolving fund in accordance with bylaws, internal rules and turns set by members;
- Every member has to obey rules and regulations and obliged to pay membership and other fees as stipulated in the bylaw governing the revolving fund;
- Group members should work hard in order to fulfil obligations stated in the binding agreement signed between their group and Office of Agriculture and can sell out the remaining ones to anybody demanding;
- Other rights and obligations.

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## Management Committee

- The management committee is a group of participants elected and supervised by the General Assembly from the members of the group.
- This group of members is in charge of the organisation and of the efficient management of the activities and resources of the group.
- Are elected on the basis of their competencies and qualities and not their social position
- In the event of poor performance, the General Assembly can change the members of the management committee.
- The General Assembly can call an emergency meeting to replace one or more members of the management committee if more than 2/3 of the members vote in favour of the idea.

    - *Composition of Management Committee*
        - Chairperson (1)
        - Record keeper (1)
        - Box keeper (1)
        - General Members (2)

    - ***Responsibilities Chairperson:***
        - Represents the Nursery Group to outsiders including Kebele and Woreda offices
        - Announce agenda, call meetings and lead and facilitate discussions
        - Ensure bye-law and rules are followed, maintain discipline and charge fines if appropriate.
        - Resolve conflicts together with observers and/or others to be elected by members
        - Has the power to appoint sub-committees if necessary

    - ***Responsibilities Record keeper:***
        - Ensures that all financial transactions take place according to procedure,
        - Keep records concerning membership payments,
        - Keep records concerning loans,
        - Provides information on financial state of revolving fund at start of every meeting,

- Balance cash box after transactions and announces amount present at end of meeting.

- ***Responsibilities of the Box keeper:***
  - Keep cash box in between meetings
  - Do not allow to open the box unless decided by the General Assembly and three authorized committee members are present

- ***Responsibilities of Observers:***
  - Count money for all transactions (membership, fines, repayments, interest & loans)
  - Inform Record Keeper of every transaction
  - Assist Record Keeper in balancing cash box and resolving any cash discrepancies
  - Assist Chairperson in resolving conflicts.

- ***Election of Management Committee:***
  - Elections are held every year
  - The members of the management committee are elected for a duration of one year
  - The maximum consecutive terms is set at two years
  - 2/3 of the members must be present to hold elections
  - At least two persons must stand for each position
  - Each nominee should be supported by at least two members

- ***Removal of members of management committee:***
  - Any member of the Self-help Nursery Group can call a vote of no confidence in an elected member.
  - If this vote carries a 2/3 majority of members, the elected member has to step down and another member has to be elected in his place.
  - If an elected member steps down voluntarily, the management committee shall appoint a replacement until the time a new member can be elected.

## Meetings

- The revolving fund members shall meet every _____ to pay membership fees, discuss requests/repayment for loans and discuss matters concerning the running of the Self-help Nursery Group/ revolving fund.
- The General Assembly should agree on the amount left in the cash box at the opening and closing of every meeting, after the money counters have performed the counting.

## Departure of members of the Self-help Group Nursery/ revolving fund group

- If a member leaves the Self-help Group Nursery/ revolving fund because he/she has no alternative and the other members agree on this, the member receives the amount contributed plus share of interest and fines collected after settling possible outstanding loans.
- If a member leaves the Self-help Group Nursery/revolving fund voluntarily and the other members agree on this, the member receives the amount contributed after settling possible outstanding loans, at the end of the year.
- At the end of the year, expelled member receives the amount contributed after settling possible outstanding loans.
- Expulsion can only take place if a vote carries 2/3 majority of the members Reasons for expulsion are:
  - _____
  - _____

- In case of death the recognized heir receives the amount contributed plus share of interest and fines collected after settling possible outstanding loans.

## Criteria for Loan Eligibility

- Factors that may be considered:

- Is the member up to date with weekly/monthly savings?
- Does the member regularly attend meetings and finish his job assignment on time?
- Does the member have experience in the activity in question?
- Do members of the group who have experience in a similar activity think the request is for a reasonable and necessary amount?
- Does the member have a reputation of being honest and hardworking?
- Does the member have a reputation for paying his/her debts?
- Does the borrower agreed in front of the public to transfer the input to one other farmer?
- The maximum input borrowed is decided in accordance with the breakdown stated in the plan and agreement reached by all members;
- The maximum length of loan is reasonably proposed by the management committee and decided by the General Assembly.

- Loans can be extended in cases of some catastrophes and/or some unexpected happenings;
- Interest is 10% of total loan to be paid at end of loan period or before extending the loan
- If interest is not allowed (e.g. Muslims) another agreed upon mechanism with equal amount can put-in-place
- If the loan is considered to be uncollectible by the members the guarantors are responsible for repayment of loan without interest after deduction of the savings of the original borrower in the revolving fund
- Other criteria

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## Funds and Savings

- All members, including management committee are obliged to pay membership fee at the start of every meeting;
- Members borrow inputs either in group or individually, supplied by donors and/or Government, in kind in order pay back similarly to farmer assigned to take it and transfer in the same way;
- Members may contribute an equal agreed upon amount at the start of each year to speed up the growth of the revolving fund;
- All funds collected in the form of membership fees, interest and fines is the property of all members but the one they get in the form of input remains seed money to rotate within whole community
- Inputs remain to be property of the Group and get enlarged to serve as a community fund so as to sustain their development endeavour and accommodate changes.

## Inputs supplied by SLMP

- Upon receiving the input, a cash payment of 10% of the agreed upon value of the input will be paid into the revolving fund;
    - Tree seedlings, grasses and Politian tube
    - Fruits, vegetables and beehives
    - Sheep, goats, poultry and inset
    - Potato, Cereals, and other root crops
- Remaining amount should be paid back in kind within agreed upon period not exceeding 52 weeks;
- If the remaining amount is not paid back within the agreed upon period the input will be collected (depending up on its kind) and distributed to another member according to the above conditions;
- If perishable he/she pays back in cash to buy and replace the input;
- The down payment reverts to the revolving fund and is lost to the member;
- Wheel barrow, watering can, spade, rake, root pruning scissors, seeding tray, pickaxe, buckets and sand sieve could be transferred in the form of start-up gift on farmers' day
- Other

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## Fines

- Non-attendance of meeting without valid reason: _____ ETB
- Late for meetings:_____ ETB
- Deviation from norms and misbehaving: _____ ETB
- Ignoring committee instructions: _____ ETB
- Failing to repay loan within agreed time: _____ ETB
- Other fines:

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## Membership List

1. Name _____ Signature_____
2. Name _____ Signature_____
3. Name _____ Signature_____

4. Name _____ Signature_____
5. Name _____ Signature_____
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24. Name_____ Signature_____
25. Name_____ Signature_____