JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NATIONAL FORESTRY SERVICE (SFN) OF THE MINISTRY OF AGRICULTURE AND LIVESTOCK (MAG), THE REPUBLIC OF PARAGUAY

THE STUDY ON REFORESTATION PLAN IN THE EASTERN REGION, THE REPUBLIC OF PARAGUAY

REFORESTATION MANUAL

MARCH 2002

JAPAN FOREST TECHNOLOGY ASSOCIATION (JAFTA)

PASCO INTERNATIONAL INC.

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INTRODUCTION

This afforestation manual explains the content of major tasks involved in the nursery practices and afforestation operations upon implementing the afforestation plan (master plan) for the eastern region of Paraguay and has been produced with the objective of being useful to technical support to personnel involved in such afforestation. The task contents are explained based on methods that are in general use with the currently available level of technology. It is hoped that through creativity and originality, this manual may be used to implement the project using efficient task methods.

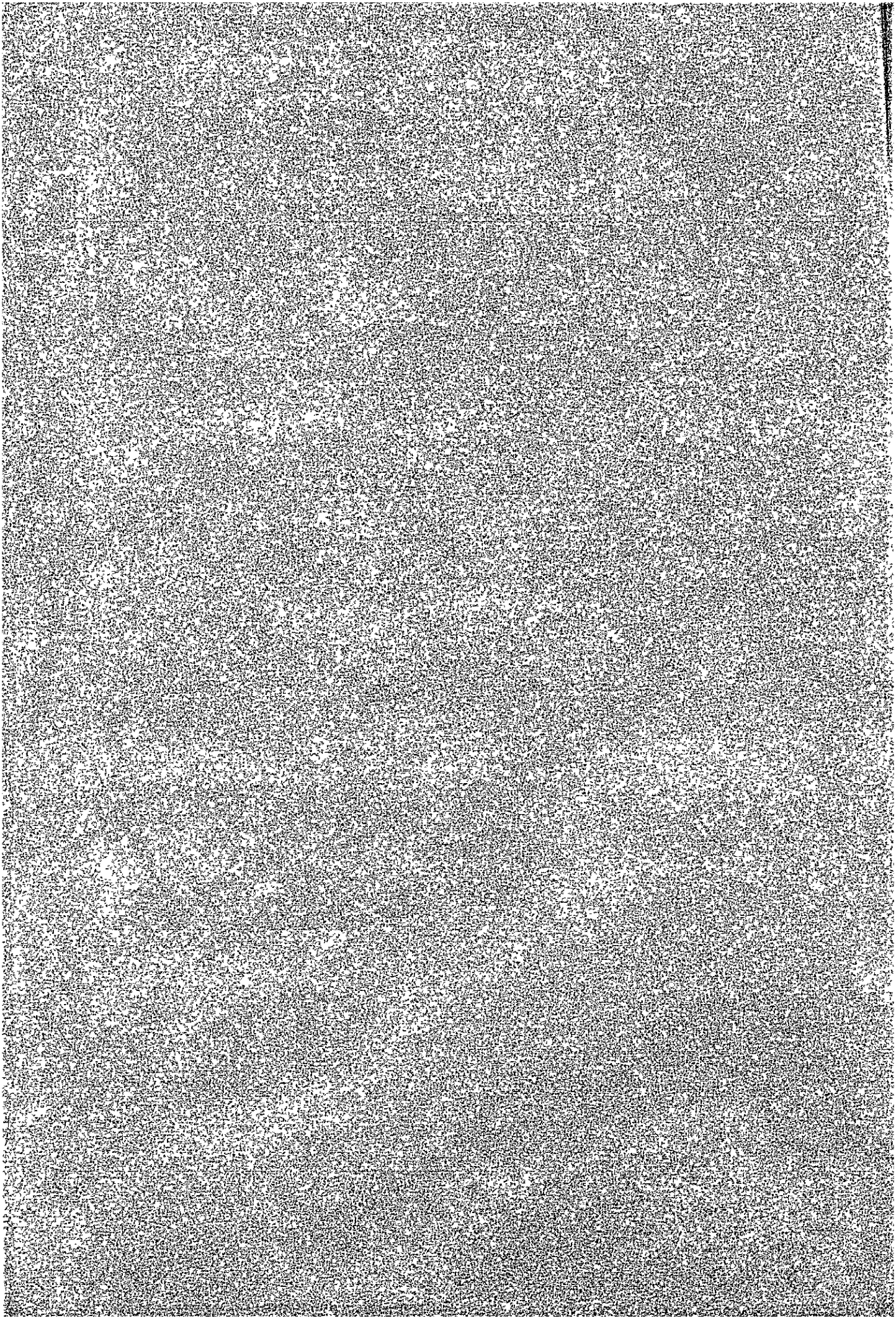
Moreover, while the method of procuring funding to implement the project is still undetermined, the manual explains application procedures for assumed methods of funding and procedures for environmental assessment upon implementation of the afforestation project in order to ensure smooth promotion of the plan.

In addition to interviews with specialists of the National Forestry Service (SFN) of the Ministry of Agriculture and Livestock (MAG) of Paraguay, professors of the Faculty of Forestry of the National Asuncion University, Mr. Hattori who lives in Asuncion and afforestation companies in Paraguay, this manual has been completed using, as reference, "Afforestation Manual (Afforestation Project in Central Paraguay, 1994" and a "Training Textbook" for the Afforestation Diffusion Project in the Eastern Region of Paraguay. Our appreciation is due to the many interested parties who has helped in preparing this document.

CONTENTS

CHAPTER I

NURSERY PRACTICES



CHAPTER I

NURSERY PRACTICES

In order to ensure creation of superior forestry, it is required to produce and supply seedling with superior growth and quality. In this section, explanation will be provided on the content of tasks from the establishment of nursery to production of seedlings following the order of task processes to the extent possible based on the above perspective.

1. Establishment of Nursery

A nursery is created not only to provide seedling required to self-supply for the area under afforestation but also to market and provide seedling to other entities involved in afforestation.

The types of seedling nursery may be broken down into fixed nursery and temporary nursery depending on the period during which the production of seedling is undertaken. Fixed nurseries are created when large numbers of seedling are to be produced over a long period spanning more than 10 years and are normally created in locations with convenient transport conditions. On the other hand, temporary nurseries are created close to the afforestation area for small scale afforestation projects or for marketing purposes and are closed upon completion of the afforestation project.

1-1 Conditions with respect to the Location of Nurseries

When establishing a nursery, the following conditions need to be taken into consideration with respect to the land and environment.

① A location with relatively high soil fertility and with terrain that is either flat or sloped 3 to 4 degrees or less

② A location that can afford land mass required for producing seedlings

③ A location with good water drainage that does not flood during heavy rainfall

④ A location with a water reservoir that can supply the required volume of water throughout the year

⑤ A location that is not a windfahne

⑥ A location with labor resources in the vicinity

⑦ A location that allows obtaining soil for pots in the vicinity

⑧ To the extent possible, a location that is close to the area under afforestation and with good access to general public roads

1-2 Area for Nursery

The area required to nursery is determined by the required volume of production of seedling and the method of production. A general rule of thumb is given in Table I-1. In the case of fixed nurseries, appended facilities such as roads, warehouses for equipment, warehouses for supplies, employee lounges and structures for housing management functions will also be required and the overall requirement is about twice the land mass required to nursery.

Table I-1 Estimate of Land Mass Required for Nurseries

Method of seedling production	Number per square meter	Seedling bed area per 100,000 seedlings	Seedling nursery area per 100,000 seedlings	Remarks
Pots (5cm)	400 seedlings	250m^2	1000m^2	Including walkways and germination beds
Pots (7cm)	196	500	2000	
Bare root seedling (conifer)	120	850	3400	
Bare root seedling (broadleaf)	80	1250	3800	

1-3 Equipment such as Machinery

In general, tasks at a seedling nursery are performed manually but the machinery used frequently in large scale fixed nurseries are tractors, trailers, trucks, water pumps, drainage pipes, power sprinklers, mixers for pot soil, forklifts, belt conveyors and refrigerators for preserving the seeds.

1-4 Tools

The tools most frequently used are wheel carts, hoes, shovels, machetes, forks, rakes, mallets, trimmers, shears for pruning high branches, ladders, transplanting tongs, watering pots, sieves, sprinklers, measuring instruments, weighing instruments, germination verification instruments and carpenter's tools.

2. Preparing the Nursery

(In this item, procedures for the potted seedling and bare root seedling will be explained together.)

2-1 Seed Bed

a. The first step in the production of seedling is producing the bed for seeding. This bed should be made using soil dressing that is appropriate to the germination and growth of the seed.
There are two types of seed beds, the framed flat bed whereby the sides of the bed are enclosed with a wooden frame (bamboo or the trunk of palm trees may also be used as a simplified method) and the flat bed whereby the soil dressing forms a mound (Figure I-1).

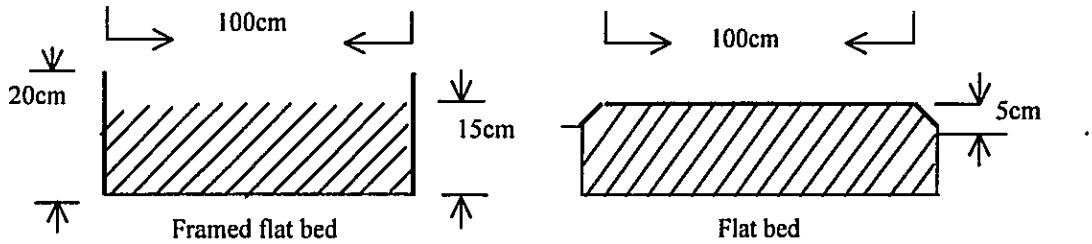


Figure I-1 Seed Bed

b. The width of a seed bed should be 1 meter while the length will depend on the situation of the seed nursery but should be within 10 meters from the perspective of work efficiency. The height should be 15cm for the framed flat bed and a mound of about 5cm for the flat bed (refer to Photo Number 1). A walkway that is 50cm wide should be made between the beds. In sandy land, the flat bed is inappropriate as the soil may flow out during heavy rain and such beds are more appropriate for clayey soil.

c. As appropriate drainage is required to the soil dressing of a seed bed, small stones should be laid to a depth of 5cm as the lower layer and sandy soil laid in the middle and surface layer using sieves with mesh of 8mm and 2mm respectively. If sieves are not available, the soil may be broken up using a rake (refer to Photo Number 2). After this procedure is completed, sterilizing chemical and herbicide are sprinkled on the soil.
When creating a seed bed in sandy soil, soil dressing should be performed with mountain soil for soil amendment and sterilizing chemical and herbicide sprinkled on the soil.

2-2 Transplanting Bed

The transplanting bed is where the germinated sapling is placed to grow to a size appropriate for transplanting in the forest. The form of the seed bed differs by the form of the seedling to be raised.

(1) Transplanting bed for potted seedling

a. A transplanting bed for potted seedling may merely be flattened ground or a location enclosed with a wooden frame, heavy duty wire or bamboo to prevent the pots from capsizing (refer to Photos Number 3 through 5). Bricks or concrete may be used in place of wooden frames but this is more prone to causing the temperature of the seed bed to rise than in the case of wooden frames and the cost is also higher. The former is most often used with sandy soil and if clayey soil is being used, the bed surface will need to be inclined with consideration given to drainage.

b. If pots with no base are to be used, regardless of other conditions of the seed bed, the bed surface will need to be inclined and covered with polyethylene sheets in order to prevent the root from growing into the ground.

c. The width of the bed should be 1 meter and the height about 15cm. The length will depend on the size of the seedling nursery and the sun covering facility. A 50cm walkway should be in place between seed beds.

(2) Transplanting bed for seedling with bare root

a. A transplanting bed for bare root seedling may be the framed flat bed whereby the sides of the bed are enclosed with a wooden frame, bamboo or the trunk of palm trees and the flat bed whereby the soil dressing forms a mound.

b. In the case of the framed flat bed, the frame is placed after digging down about 4 to 5cm and soil dressing is placed in the frame preventing the soil from overflowing over the frame. In the case of the flat bed, no soil dressing is generally performed but if the soil of the nursery is extremely sandy or clayey, it is recommended that soil dressing be performed only at the seed bed.

c. The soil used in soil dressing should be the same as the soil used in the pots. When doing this, if the original soil is clayey, sand is admixed (top soil 9: sand 1). In the case of sandy soil, there is no need to admix sand.

d. The size of the seed bed and the distance between the seed beds are the same as for the potted seedling.

2-3 Watering Facility

a. Watering the seed bed or transplanting bed is a task that needs to be performed daily and the condition of maintenance of this facility is key to the efficiency of seedling production. Watering facilities differ by the condition of the water reservoir and the scale of the nursery. Ideally, automatic watering using a sprinkler should be the main equipment used with watering from a water tank used as a supplementary method.

b. Seed beds immediately after seeding or transplanting require watering in the form of mist and in order to provide this, the installation of a sprayer is desirable. For smaller seedling nurseries, a watering pot with small openings will suffice.

2-4 Sun Covering Facility

a. A sun covering facility is required to adjust the temperature and humidity of a transplanting bed or seed bed and to prevent drying.

b. Methods of sun covering involve covering each bed separately or covering a plurality of beds together.
The former method may involve covering the frame of the seed bed (low covering), erecting poles to a height of about 70cm on the outer perimeter of the seedling bed and supporting the covering using wires (square covering, refer to Photo Number 6) or supporting the covering itself using wire stands (round covering).
The latter involves erecting poles to a height of about 2 meters to support the covering (high covering, refer to Photo Number 7). In this case, it is possible to work on the beds in a standing position but on the other hand, the covering cannot be removed and the seedling may become unproductive so that care is required when choosing this method.

c. The material used in sun covering may be bamboo, planks, branches, cheesecloth or vinyl and the most available material should be used. Care is required when using bamboo or planks as this may cause inadequacy of sunlight.

3. Production of Seedling

Figures I-2 to I-3 show the process of production of seedling in the case of potted seedling and bare root seedling. The explanation of the tasks involved in production of seedling using potted seedling or bare root seedling will be provided following the order of the tasks shown in the figure to the extent possible.

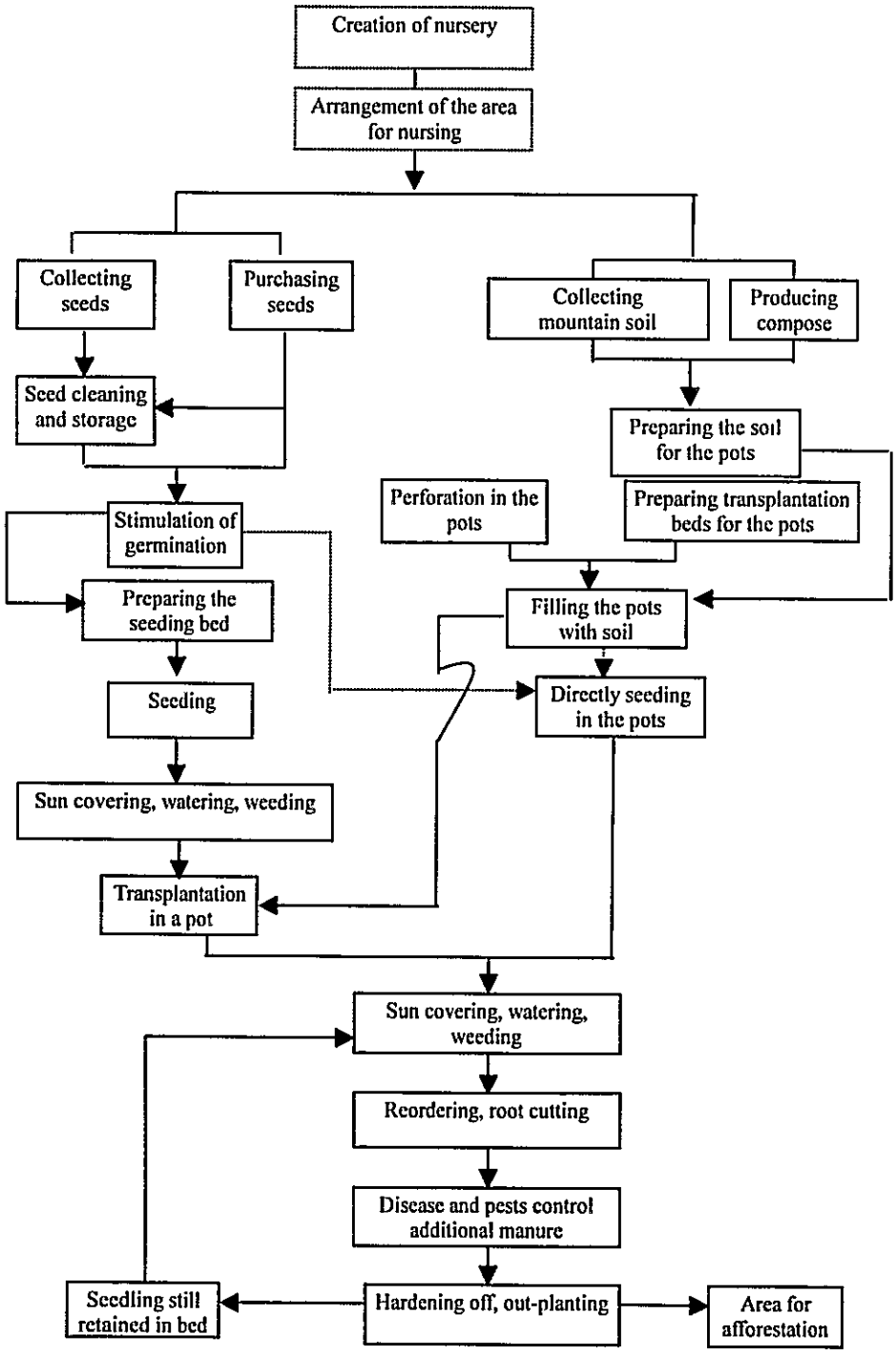


Figure I-2 Process of Production of Potted Seedling

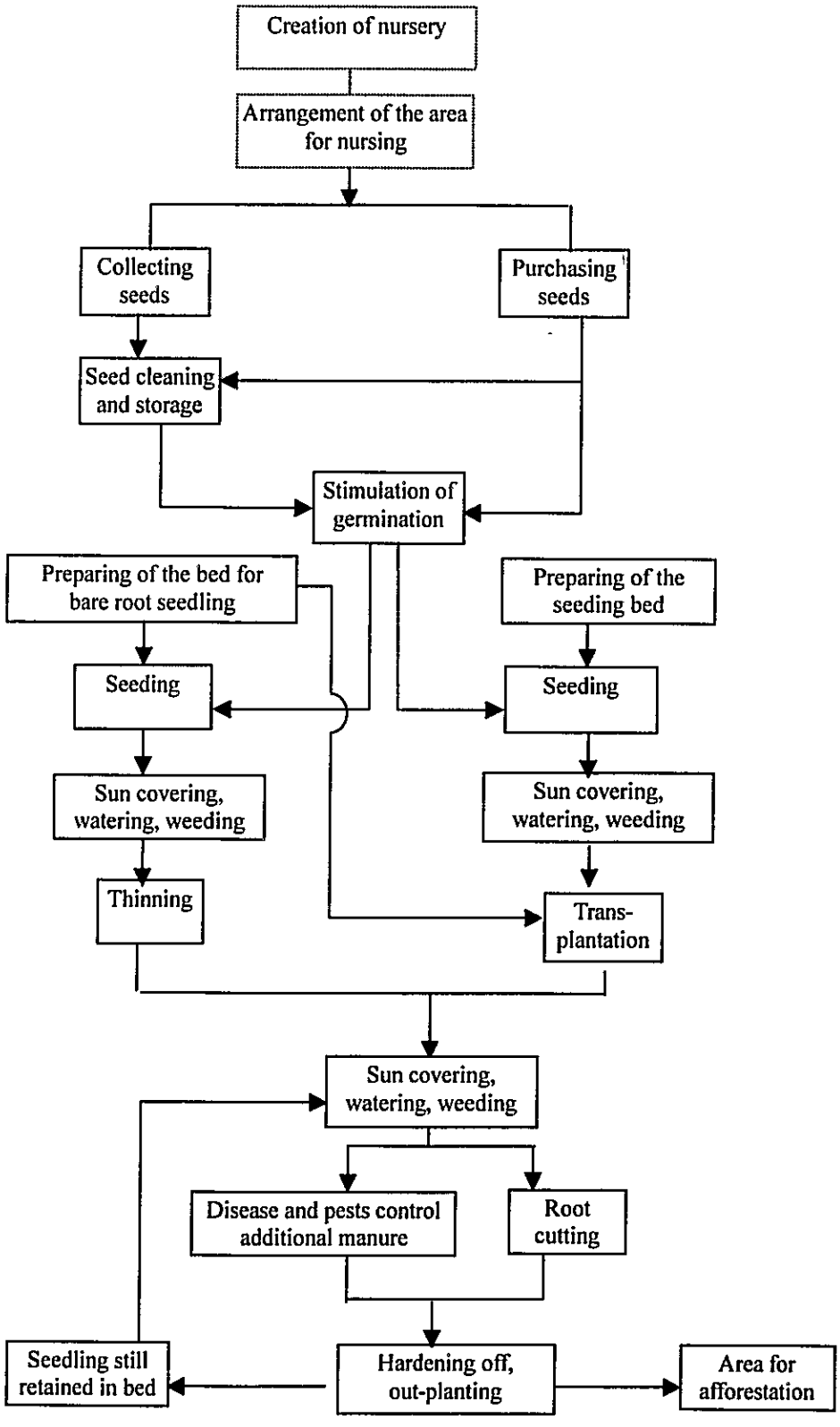


Figure I-3 Process of Production of Bare Root Seedling Root

3-1 Obtaining Seeds

(This item is common to both potted seedling and bare root seedling.)

(1) Required amount of seeds

Seedling from seeds is the general method of seedling production as this allows producing a large number of them at a time. Once the requirement with respect to the number of seedlings required has been determined, the seed requirement is obtained from the following formula for each specific tree species.

$$\text{Seed Requirement (kg)} = \frac{\text{(Number of Seedling Scheduled to be Planted)}}{\text{(Rate of Germination *}^2 \times \text{Rate of Transplantation Seedling from the Seeding Bed *}^3 \times \text{Rate of Seedling of Out-planting *}^4\text{)}} \Big/ \frac{\text{Seed Particles}}{\text{per kg *}^1}$$

*1: The number and weight of the seeds: As shown in Table I-2.

*2: Rate of Germination: (The number of seeds that germinate normally) / (The number of seeds used in the germination test); (Refer to the explanation below on the method of germination test)

*3: The proportion of seedlings that may be transplanted to the transplantation bed or pot from the germination bed.

*4: The number of seedlings that may be planted in the forest from among those that are transplanted to the transplantation bed or pot.

Table I-2 Number and Weight of the Seeds of Principal Tree Species

Species	Particles per 100g	Weight per liter (g)	Species	Particles per 100g	Weight per liter (g)
P.taeda	4,250	565	G.robusta	5,930	240
P.elliottii	3,040	528	Lapacho	3,250	120
E.grandis	87,000	480	Petereby	2,880	135
E.camaldulensis	53,000	461	Guatambú	262	53
E.saligna	29,000	518	Ybyra ró	1,040	1,530
E.citriodora	12,200	531	Ybyra pyta	1,000	800
M.azedarach	200	439	Timbó	480	745

Source: "Training Textbook" for the Afforestation Diffusion Project in the Eastern Region of Paraguay

After determination of the seed requirement, the method of obtaining the seeds will need to be reviewed. Seeds may be purchased on collected.

Method of Germination Test

Determining the germination ratio of stored seeds and newly harvested seeds is necessary in order to grasp the appropriate amount of seeds to be seeded, to mitigate the work required in thinning out in the event seeding is excessive and for the efficient use of expensive seeds.

The methods of germination test include a method of actually causing the seeds to germinate, cutting the seeds and observing and using chemicals. Here, a simple explanation shall be given on the method of actually causing the seeds to germinate, generally the simplest method available, and the method of cutting the seed and observing.

1. The method of actually causing the seeds to germinate

   The germination ratio is obtained using the following formula.

$$\text{Germination Ratio (\%)} = \frac{\text{(Number of seeds that bud normally)}}{\text{(Number of seeds used in the test)}} \times 100$$

   ① Number of seeds used in the test: After mixing the seeds to be subjected to the test, four groups of 100 seeds are randomly created. In the case of large seeds such as Paraiso gigante, 50 or 25 seeds may comprise one group. Moreover for such plants as eucalyptus with extremely small seeds, it is possible to consider 0.1g as being a group as an adaptation of the method of actually counting the seeds.

   ② Number of seeds that bud normally: This refers to the number of seeds that exhibit the radicle elongating in a straight manner and growing to a length greater than that of the seed. In this case, seeds with coleoptile appearing at the tip, twin seeds, injured buds and buds with no coleoptile or radicle are not counted as budding normally.

   ③ Method of germination test: Three sheets of filter paper soaked in distilled water are placed in a petri dish with a diameter of about 9cm (wool may also be used) and 100 seeds (after processing to stimulate germination in the case of seeds that require this process) are placed on the filter paper. This is placed in a location where the interior lighting conditions are stable (ideally exposed to sunlight about 8 hours a day). Germination is investigated from the 7th day and the investigation is discontinued on the 20th day (this may differ depending on the species; the idea is that almost all seeds germinate and after this point, germination is sporadic). The

number of seeds that have germinated normally to this point is counted. During the test, water is supplied to the filter paper to maintain moisture.

④ Germination ratio: The germination ratios for the 4 groups are calculated and the average of these values is the germination ratio of the seed in question.

⑤ If possible, the date on which the greatest number of seeds germinate should be identified and the number of seeds that germinate up to this date counted and divided by the seeds subjected to the test to obtain the germinating power of the seed. Since seeds that germinate in a shorter period of time have stronger germinating power and can be expected to grow healthily in the nursery, this indicator can be expected to be close to the ratio of seedlings obtained at the transplantation stage.

2. The method of cutting and observing the seed

Obtain 500 particles of seed and cut all the seeds using a knife to investigate the cut. Seeds in which the embryo is moist, vivid and ripe are considered good seeds. The number of such seeds in the 500 seeds subjected to the test determines the germination ratio. Seeds with embryos that are somewhat dry, discolored and shrunken are considered to have inferior germination power. Care needs to be taken in using this method as the germination ratio tends to evaluated higher than appropriate.

(2) Purchase of Seeds

There are few trees from which superior seeds with clear historical record may be harvested in Paraguay and a system for the structured supply of such seeds is yet to be put in place.
For this reason, in order to afforest areas with high growth, except in cases where superior seeds with clear historical record may be harvested, it is considered desirable to procure superior seeds from abroad for such non-indigenous species as eucalyptus, pine and pariso gigante. Moreover, in the case of indigenous species, seeds should be harvested from superior natural trees within the country.
The Servico Forestal Nacional (SFN) has certain superior non-indigenous and indigenous species for harvesting purposes and seeds may also be procured from this source.
For reference purposes, Table I-3 provides a list of suppliers of seeds.
In the case seeds are to be procured, it is important that orders request the provision of such information as the name of the species, country/region of origin, location at which the seeds

were harvested, date of harvest, weight per unit number of particles (in grams) and storage conditions.

Table I-3 Suppliers of Seeds (Example)

Supplier	Country	Address	Seeds supplied
CHAMPION	BRASIL	RODOVIA SP 340km 171-13840-970 MOGI GUAZU SP, BRASIL. TEL.19-861-8603, Fax. 19-861-8210	Eucalyptus, pine
CRISO	AUSTRALIA	PO BOX E 4008,KINGSTON ACT 2604, AUSTRALIA.TEL.02-6281-8211, FAX.02-6281-8286,	Eucalyptus, pine
EXPORTADORA DE PRODUCTOS AGROPECUARIOS AGROPASO LTDA.	BRASIL	RUA ASSIS BRASIL-521-VILA PORTES FOZ DO IGUAZ, BRASIL. TEL/FAX.045-523-3037-522-3236	Eucalyptus, pine
IPEF	BRASIL	CAJA POSTAL 530- PIRACICABA, SP-CEP13400-970 BRASIL, 19-430-8615-8616	Eucalyptus, pine
SCHUCKAR	BRASIL	PRACA DAS CEREJEIRAS 1-50-17-040-500 BAURU,BRASIL TEL/FAX.65-014-223-6023	Eucalyptus
KLABIN FABRICADOR DE PAPEL E CELULOSE SA.	BRASIL	FAZENDA MONTE ALEGRE, BRASIL TEL.0422-72-2502	Pine
INTA	ARGENTINA	ENTRE RIOS, CP 3200 ARGENTINA	Eucalyptus
POOL FORESTAL	ARGENTINA	ENTRE RIOS, CP 3200 ARGENTINA TEL.011-47438601	Eucalyptus
S.F.N.	PARAGUAY	RUTA 2KM, 10 -SAN LORENZO 575-564	Eucalyptus, pine, indigenous species
DANZER FORESTACIONES S.A.	ARGENTINA	"El porvenir"Casilla de correo 449-Código postal, TEL 254-0752-21396 y 254-0752 80295	Paraiso gigante

(3) Harvesting

The maturation period of seeds depends entirely on the species. In general, as the maturation process progresses, the color of the fruit changes from green to yellow or brown and when completely matured, the fruits individually fall to the ground or the fruit breaks on the tree and the seeds fall to the ground.

As methods of harvesting seeds, there is the method of collecting the fruits or seeds that have fallen to the ground or harvesting prior to this while the fruit is still on the tree. The former is only used for such species with large seeds as timbo and guatambu and for most species, the latter method is used. The timing of the harvest is determined by the color of the fruit. In reality, the maturation period fluctuates widely by the location of the parent tree and for this reason, consideration should be given to periodic observation in order that the right timing for harvesting is not lost.

Harvesting the fruits from the tree may involving climbing the tree, pulling the branches with

the fruit close to obtain the fruit or cutting the branches with fruits. Tools used in harvesting to achieve greater efficiency are ladders, climbers and shears for cutting high branches. Table I-4 shows the timing of maturation by species for reference.

Table I-4 Season for Fructification of Principal Tree Species

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
M.azedarach (p.gigante)				―	―	―	―					
E.grandis (Eucalipto)					―	―	―	―				
E camaldulensis (Eucalipto)					―	―	―	―				
Pinusspp. (Pino)		―	―	―								
G.robusta (Grevillea)	―											―
Peltopharum dubium (Yvyra pyta)				―	―	―	―	―	―	―		
Pteroyne nitens (Yvyraa ro)	―	―	―									
Balfourodendron r. (Guatambú)			―	―	―							
Tabebuia heptaphylla (Lapacho negro)								―	―	―		
Tabebuia impetiginosa (Lapacho rosado)									―	―	―	―
Cordia trichotoma (peterevy)			―	―	―	―						

Source: "Training Textbook" for the Afforestation Diffusion Project in the Eastern Region of Paraguay

3-2 Seed Cleaning and Storage of Seeds

(1) Cleaning Seeds

In order carefully to select the seeds harvested, it is necessary to separate the seeds from the fruit. The form of the fruit differs by the tree species and the method of separation differs accordingly.

a. Tree species with respect to which seeds are easily separated from the dried fruit (Eucalyptus, Pine)

The fruit is spread on a sheet and exposed to sunlight and wind to dry. This allows the seed to be separated easily from the fruit. After drying, the fruit is lightly tapped to remove the fruit and the remaining seeds are passed through a sieve to remove any extraneous materials (refer to Photos Number 8 through 11).

b. Tree species with fruity seed coating (Paraiso, Pacuri, etc.)
Water is placed in a drum can and the seeds immersed for one to two weeks together with the fruit. When the fruit rots, the seeds are taken out and placed in a sieve and the fruit and seeds are separated by mashing the content with gloved hands as water is poured over the content. After this, only the seeds are spread on a sheet and dried by exposing to sunlight and wind (refer to Photo Number 12).

c. Tree species with respect to which the fruit splits open upon drying but the seed remains difficult to separate (Lapacho, Grevillea, etc.)
The hands are used to pulverize the fruit and separate the seeds. The seeds are carefully selected by eradicating extraneous materials using wind and other resources.

d. Tree species with extremely hard seed coating (Ybyra pyta, Ybyra ro, Leucaina, etc.)
A barley breaker used in thrashing corn is used to pulverize the seed coating and remove the seeds. The seeds are carefully selected by eradicating extraneous materials using wind and other resources.

(2) Storage of Seeds

a. Among seeds there are those that lose germinating power within a few days from harvest and others that may be dried and stored. Among the former, many seeds have seed coating that is relatively soft and without wings (this also applies to Petereby) and these seeds need to be recovered and seeded as soon as possible after harvesting. Most seeds may be stored.

b. The seeds of eucalyptus, pine, paraiso, lapacho, guatambu, petereby, yvyra pyta, yvyraa ro and other species may be stored. Normally it is possible to store these seeds for up to 2 to 3 months without reducing the activity of the seeds by placing them in a plastic or metal container with small air holes and placing the container in a dark and dry environment at between 0 and 5 degrees centigrade. It is possible to preserve these seeds for 2 to 3 months even in a home refrigerator. However, long-term storage will weaken the germinating power of the seeds. SFN is conducting tests of long-term storage (2 to 3 years) and it has been found that storage at minus 24 degrees centigrade maintains germinating power best and seeds stored at 4 degrees centigrade followed.
However, in general, if storage facilities are not adequate, it is best to refrain from procuring excess seeds and seeds should be procured as they become needed.
When storing seeds, the name of the species, the place at which harvested, the date of harvest, weight of the seeds per unit, date of seed selection, date of commencement of storage and method of storage should be recorded. Table I-5 shows an example of this.

Table I-5 Seed Record

The name of the species	Record	Remarks
The place of harvest		Staff responsible for storage:
The date of harvest		
Weight of the fruit per unit quantity (g)		
Weight of the seeds per unit quantity (g)		
Date of seed selection		
Conditions of storage		
Date of commencement of storage		

3-3 Stimulation of Seed Germination

a. Among seeds, there are those with extremely hard seed coating that do not readily absorb water or oxygen thus requiring a long time to germination while others germinate quickly but at staggered rates. If a long time is required to germination, there is the danger of various damage being inflicted in the interim period. On the other hand, if germination is staggered, there will be a difference in later growth thus making it difficult to obtain uniform seedlings. In order to overcome these problems, measures to stimulate germination need to be taken prior to seeding. These measures differ by the tree species.

b. In general, there is no need to perform germination stimulation for eucalyptus, pine, paraiso, lapacho or petereby. However, seeds of pine that have been stored for 3 years or more should be immersed in water, placed in a vinyl bag and allowed to stand in a refrigerator for 2 to 3 days at between 3 and 4 degrees centigrade. After this, the seeds are taken out and dried in shade and stored again for 40 days in a refrigerator prior to seeding.
In the case of ybyra pyta, ybyra ro and guatambu, the seeds are immersed in ordinary water for 48 hours prior to seeding. The seeds of grevillea should be immersed in water at 80 degrees centigrade for 1 to 2 minutes prior to seeding as this will hasten germination and increase the germination ratio compared to seeds that have not been so treated.

3-4 Production of Potted Seedlings

3-4-1 Preparing the Pot Soil

a. The conditions required of pot soil are that water seeps in when the soil is irrigated, that the soil does not disintegrate easily when the pot is removed and that the soil supplies the nutrients required for the seedling to grow.
Accordingly, the soil to be placed in a pot should be appropriately clayey, have good draining properties and have ample nutrients.

b. In general, soil prepared by mixing the top soil from forests with sand is used. The proportion of admixing is generally 9 parts top soil to 1 part sand by volume. If the clay content of the top soil is high, the proportion of sand should be increased while no sand is admixed in top soil from sandy areas.

c. Collection of top soil may be performed as and when required. If the location for collecting such soil is far or if mechanical power is to be used in collecting the soil, soil may be collected en masse in one operation and stored in a location that is not exposed to rain. When collecting top soil, large branches should be removed prior to the operation and the depth of collection should be between 10 and 30cm (refer to Photo Number 13, Figure I-4). The collected top soil should be sieved to eradicate extraneous materials (refer to Photo Number 14).

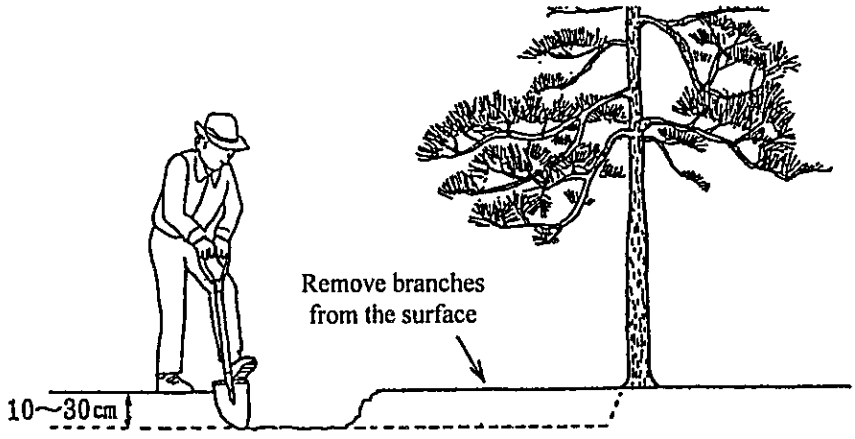


Figure I-4 Method of Collecting Forest Top Soil

Moreover, the sand to be mixed into the top soil may be river sand but if this is difficult to obtain, sandy soil may be used in its place.

d. If organic content is inadequate even with forest top soil or when using soil other than forest top soil, it is a good idea to admix compost in the top soil.
Materials that may be used as fertilizer include weed, livestock excrement and sawdust and of these, matured sawdust fertilizer is uniform in form and easy to use. Moreover, mixing livestock excrement into sawdust compost also provides a superior product. The proportion in which the soil is mixed with compost is ten parts to one part by volume. (A method of determining the mixing proportion is to taking ten shovels full of soil and mixing one shovel

full of compost.)
Moreover, if fertilizer is not readily available, chemical fertilizer may also be used. In this case, chemical fertilizer with low nitrogen content (about 6:12:8 of N:P:K) should be used. A rule of thumb in the proportion to be used is about 1 kilogram of chemical fertilizer for 1 cubic meter of pot soil. Care should be taken as the seedling may be damaged by excessive use of chemical fertilizer.
Other examples of soil that may be used is a 5:3:2 admixture of top soil, sawdust and poultry excrement and charcoal meal.

e. Mycorrhiza germs are admixed into the pot soil for pine. Mycorrhiza germs are collected together with the top soil by removing the fallen leaves in pine forests and collecting the white hypha.

3-4-2 Selection and Perforation of Pots

a. Vinyl black pots are sold on the market and these are generally in use as they control the growth of algae and promote the growth of the root.

b. The diameter of the pot should be between 5 and 7cm for eucalyptus and pine with a height of between 10 and 15cm and a diameter between 7 and 10cm and height of 15cm for paraiso and other indigenous species.

c. Four holes for draining water should be perforated about 2 to 3cm from the bottom of the pot prior to filling with soil. This may be accomplished by laying the pot flat and using an office hole puncher or using a nail on a plank and making the holes after filling the pots about full (refer to Photo Number 15).

3-4-3 Filling the Pots with Soil

a. Soil is packed hard to the brim of the pot (refer to Photos Number 16 through 17 and Figure I-5). When doing this, the pot should be held in both hands and lightly tapped on the ground in order to prevent any gaps from forming.

Good Poor

Figure I-5 Good and Poor Examples of Filling the Pot with Soil

b. When an adequate number of pots have been filled they are taken to the pot transplanting bed and placed in the required position. When doing this, the pots should be placed starting at the wooden frame in order to prevent capsizing (refer to Photos Number 18 and 19).

3-4-4 Seeding

Early spring is the most appropriate season for seeding. Seeding may be performed directly to the pots or at the seeding bed.

(1) Direct seeding to the pot

This method is appropriate for seeds of a size that allows taking each seed in the hand for seeding (such as paraiso) and if the germination ratio is greater than 50%, the seed is placed directly in the pot and grown as seedling for planting in the forest. (Certain large enterprises use an automatic seeding machine for seeding eucalyptus, the seeds of which are small, but this is not the general practice.) This method abbreviates the transplantation task and has the advantage of preventing losses from withering as a result of transplantation.

a. The number of seeds placed in a pot is 2 if the germination ratio is about 50% and 1 if the germination ratio is 70% or higher.

b. Seeds (including seeds that have been processed to stimulate germination) are placed in a hole (with depth of about 3 times the diameter of the seed) made in the pots under the sun cover using a stick. The seeds are then covered with soil to a depth of about twice the diameter of the seed and the soil is lightly pressed down using the fingers. After this, the pot is watered using a sprayer or water can.

c. Germination is confirmed about 3 weeks after seeding. If two buds have appeared, one bud is transferred to a pot with seeds that have not germinated. If there are still pots that exhibit no germination, the seeding process is repeated.

(2) Seeding to the seeding bed

This method is generally used even for those seeds that can be directly seeding to pots. The seedling is transplanted to the pots after germination.

a. If eucalyptus or pine is being seeded, since there is the danger of damping off, the soil is treated with a sterilizing chemical prior to seeding bed. (For example, a solution made by dissolving Tratalmacigo (powder) 200g in 20 liters of water is sprinkled over 20 square meters of seeding bed.)

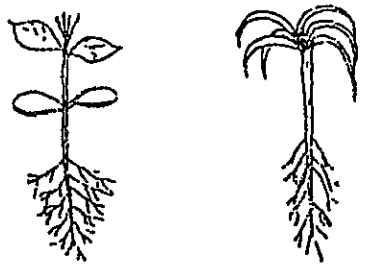
b. Procedure for seeding
The procedure for seeding is as follows.

Method of seeding	Applicable tree species	Procedure for seeding
Broadcast sowing	Species with small seeds such as eucalyptus and pine	After uniformly scattering the seeds onto the seeding bed (eucalyptus: about 6 grams per square meter; pine: about 15 grams per square meter) press lightly on the soil using a pressure plate. After this, cover with burnt soil or sand (river sand in the case of eucalyptus) using a sieve to a depth of about twice the diameter of the seeds. After covering the seeds, water as in the case of direct seeding to pots and install the sun cover (refer to Photos Number 20 through 22)
Line sowing	Species with medium sized seeds such as paraiso and grevillea	Prior to seeding, cut ditches in the soil using a tool designed for this purpose (depth about 5 to 10mm, spacing between 15 and 20cm). Scatter the seeds evenly into the ditches and hold down with the tool for cutting ditches (refer to Photos Number 23 and 24). After this, cover with soil and sun cover as in the case of the sowing method.
Single seed sowing	Species with large seeds	Create a ditch (depth 5 to 10mm, spacing 15 to 20cm) as in the case of the drilling method and place seeds individually in the ditches so that the seeds just touch each other. After this cover with soil and sun cover as in the case of the broadcast sowing method.

3-4-5 Transplantation

a. When the young seedling that has germinated in the seeding bed has grown to between 3 and 5cm in height, it is transplanted to the pot transplanting bed that has been prepared in advance. If the young seedling grows too large, the roots will become long and the apper pant of seedling above the soil surface large thus making the seedling difficult to be rooted. For this reason, care is required in the time for transplantation.
In the case of eucalyptus that has broad leaves, the correct time for transplantation is when 3 to 4 leaves have opened. On the other hand, the correct time for transplantation for pine is

when the main leaf has opened (refer to Photo Number 25 and Figure I-6). If four or more leaves have opened for eucalyptus, the lower leaves are cut using a pair of shears to reduce evaporation from the young seedling and promote to be rooted. Furthermore, for young seedling that has excessively long roots, the tip of the root is cut using a scissors (refer to Photos Number 26 through 28 and Figure I-7).



Broadleaf plant Coniferous plant

Figure I-6 Correct Time for Transplantation

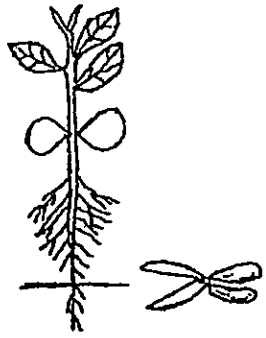


Figure I-7 Selective Cutting of the Root

b. The young seedlings are extracted in the morning or early evening. When doing this, in order to prevent damaging the roots of the young seedlings, the germination bed is watered prior to the process. A stick sharpened like a pencil, with diameter of 1cm and length 15cm is avoidable to lift the root. The young seedling extracted from seeding bed is placed in a bucket filled with water to maintain moisture to the young seedling (refer to Figure I-8).

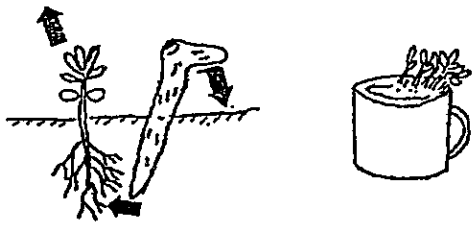


Figure I-8 Digging out the Young Seedling

c. When transplanting the young seedlings into the pots, care is taken to ensure that the roots do not curl in the soil. After placing the young seedlings in the pots, a stick is used to ensure that the soil adheres to the root and this completes the transplantation process (refer to Photo Number 29 and Figure I-9)

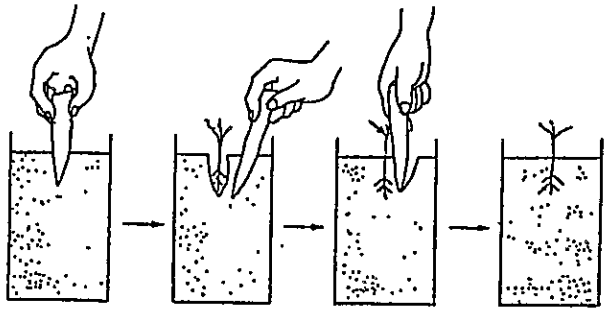


Figure I-9 Procedure for Transplanting into Pots

d. Upon transplantation, young seedlings that are deformed or are infested with pest are eradicated. Moreover, in order to prevent disease after transplantation, care should be taken to avoid holding the root and the young seedling should be held by the leaves (refer to Figure I-10).

e. Finally, the transplanting bed should be watered with mist and covered against the sun.

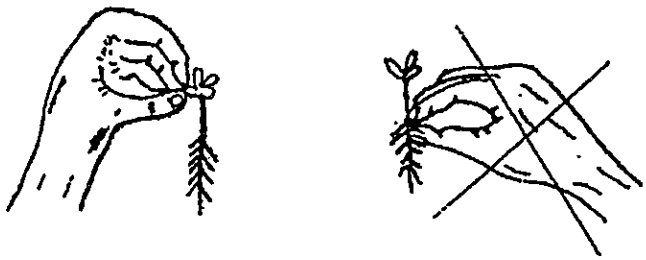


Figure I-10 Method of Holding the Young Seedling upon Transplantation

3-4-6 Sun Cover on the Seeding Bed and Transplanting Seedling Pot

a. A sun cover is installed on the seeding bed, direct seeding pots and transplanting seedling pots to prevent drying and excess heating.

b. From seeding to commencement of germination and from transplantation to the young seedling taking root, (about 10 days), the sun cover (that allows about 50% of sunlight to pass through) is maintained throughout the day and night. However, during rainfall, the cover causes the raindrops to increase in size and this digs out the seed or young seedling and for this reason the cover should be removed. When the young seedling takes root, the need for the sun cover gradually decreases.

3-4-7 Watering of the Seeding Bed and Transplanting Seedling Pot

a. As the moisture in the soil in the seeding bed or pot differs by season and climate, watering is performed when the soil is dry.

b. From seeding to commencement of germination and from transplantation to the young seedling taking root, watering is performed using mist.

c. When the young seedling takes root about 10 days after transplantation, watering is switched to sprinkler or watering pot. Watering is performed twice each day, in the morning and early evening. When doing this, the absorption of the water at the surface of the soil is observed in order to avoid excessive watering. The rule of thumb for the volume of water used is 10 liters per square meter.

d. When the height of the seedling exceeds 20cm, watering is kept to a minimum depending on the dryness of the soil. For sandy soil or soil with little organic content, watering is performed every day.

e. Between one and two months prior to transplanting to the forest, the frequency of watering is limited to once a day depending on the condition of the seedling and further limited to once every two days in order to raise the resistance of the seedling to dryness.

3-4-8 Weeding

The following procedures are used in weeding the seeding bed and transplanting seedling pot.

a. The soil in the seeding bed and transplanting seedling pot contains seeds of weeds and these seeds germinate and grow from time to time. If the weeds are allowed to grow, the seedlings are at a disadvantage in competition for light, moisture and nutrients thus restricting growth and sometimes leading to withering. For this reason, weeds need to be eradicated from the seeding bed, direct seeding pot and transplanting seedling pot on an everyday basis and in a timely manner.

b. The method of weeding involves use of herbicide or manual weeding. To the extent possible, manual weeding is recommended. When doing this, the soil is moisturized through watering prior to weeding in order to prevent damage to the root of the seedling (refer to Figure I-11).

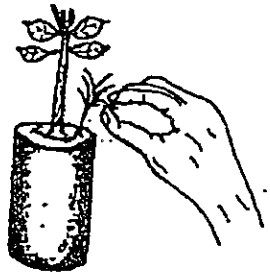


Figure I-11 Weeding the Transplantation Pot

3-4-9 Reordering the Pots and Root Cutting

a. In order to ensure that the seedlings transplanted to the pots grow uniformly in size, after direct seeding and germination or transplantation to the pot, the pots are reordered to ensure uniform lighting.

b. The time for this reordering is when 50% of the seedlings have grown to 20cm. At this point, the pots are removed from the seeding bed and pots with large seedlings are placed at the center and those with small seedlings are placed at the perimeter of the seeding bed.

c. Concurrent to this reordering, roots grown out of the drainage holes at the bottom of the pots are selectively cut using a pair of shears. By doing this, epinastic growth of the seedling is prevented and the growth of rootlets promoted (refer to Photo Number 30).

d. The above tasks should be performed in cloudy weather to the extent possible and the bed should be irrigated upon completion of the tasks.

3-4-10 Disease and Pest Control

(1) Damage from diseases

a. The most common disease found in seedling nurseries is damping off that causes the root or stem of seedlings immediately after germination to rot. Eucalyptus and pine are particularly susceptible to this disease.
Prevention is the most effect measure against this disease. It is important to sterilize the seed and seeding soil prior to seeding. If this disease is contracted after germination, spread of the disease should be prevented by spraying with chemicals.

b. Mold may also occur in seedling and this needs to be addressed by sterilizing the seeds.

(2) Pest

The major damages caused by pests are by caterpillars, ticks, cockroaches and leaf cutter ants that eat the leaves and absorb the sap. If the extent of the damage is widespread, chemicals will need to be used.

(3) Example of Pest Control using Chemicals

Table I-6 shows the example of pest control using chemicals performed by the National Forestry Service (SFN) of the Ministry of Agriculture and Livestock (MAG) of Paraguay.

Table I-6 Example of Disease and Pest Control using Chemicals (MAG-SFN)

Name of the chemical (brand name)	Purpose	Location of use	Method of use
BENLATE	Damping off	Seeding bed, transplantation pot	Sprinkle the chemical in a concentration of 20 to 30 grams per 10 liters
SEVIN	Caterpillar	Seeding bed, transplantation pot	Same as above
TRATALMACIGO	Damping off, leaf cutter ants, other diseases	Seeding bed	Sprinkle the chemical in a concentration of 200 grams per 10 liters
DITHANE M80	Sprinkle the chemical in the path taken by the ants	Seeding bed, transplantation pot	Sprinkle the chemical in a concentration of 20 to 30 grams per 10 liters
HOMAI	Disease caused by mokds in general	Seeds	Sprinkle 2 to 3 grams of this chemical on 1 kilogram of seed
CEBO	Leaf cutter ants	Nursery and pathways of the ants surrounding it	Sprinlle this chemical along the pathways of the ants
FORMIREX	Leaf cutter ants	Nursery and ant colonies surrounding it	Sprinkle the chemical at the entrance of the ant colony

3-4-11 Climatic Damage

Climatic damages generally seen in a seedling nursery are damages from frost and from raindrops.

(1) Frost damage

Damage from frost is prevented by installing a sun cover at night when the temperature is expected to fall or watering early in the morning if such a facility is available.

(2) Raindrop damage

(3) The small seeds of eucalyptus or pine that are seeded in a germination bed without roof cover may scatter with the soil as a result of raindrops thus preventing germination. A transparent roof such as made from vinyl should cover the germination bed until

germination and the seedling bed should be covered with straw or chaff to prevent such damage (refer to Photo Number 31).

3-4-12 Additional Manure

In general, the potted seedling after transplantation will grow sufficiently with the nutrients in the pot soil but if growth is not adequate, additional manure is performed. For example, 5 grams of Ferti Field (brand name) that contains N, P and K as main ingredients are dissolved in 5 liters of water and sprayed using a sprinkler.

3-4-13 Hardening off

a. This task is required to ensure that the seedlings in the nursery becomes accustomed to the natural conditions of the location to which they will be transplanted and is performed to increase the ratio of root taking upon transplantation. Concretely, the frequency of watering is reduced and the plant gradually exposed to stronger sunlight to promote lignification of the seedling. This process should begin when the seedling exceeds 20cm in height.

b. With respect to sun cover, the periods during which the cover is removed such as at night, on cloudy days, in the morning on sunny days and eventually all day is gradually increased to expose the plant to the sun.

c. Watering is reduced to once a day and, observing the condition of the seedling, to once in two days in order to make the seedling more resilient to dry conditions.

d. For potted seedling of species such a eucalyptus that grows quickly, the distance between pots should be increased somewhat when the hardening off process is being undertaken in order to provide space for the branches and leaves to spread adequately. In this case, a plank with width of about 5cm may be placed between the pots to prevent the pots from capsizing.

3-4-14 Planting-out to Afforestation Areas

a. The conditions that a seedling should have upon being transplanted to the afforestation area are that growth has been adequate, branches are growing in all directions, the root diameter is large in proportion to the height of the seedling and that the roots extend in all directions with numerous rootlets.

b. The general criteria for planting-out to the afforestation area are that the above standards are satisfied and that the height of the seedling is about 30cm.

c. Those seedlings that do not satisfy these criteria should remain in the transplanting bed and transplanted to the afforestation area only after the criteria have been met (refer to Photo Number 32).

d. On the day of transplantation to the afforestation area, the pot should not be watered in order that excessive moisture does not induce rotting.

3-4-15 Reference

Table I-7 shows actual examples of various major items involved from seeding of the potted seedling to transplanting in the area of afforestation for major species handled by National Forestry Service (SFN) of the Ministry of Agriculture and Livestock (MAG) of Paraguay.

Table I-7 Germination Ratio, Period of Seedling Raising and other Elements for Major Species

Species	Germination ratio (%)	Number of days to germination	Ratio of seedlings yielded upon transplantation from the seeding bed (%)	Period from transplantation to transplanting in the area of afforestation, ratio of seedlings planted in the area of afforestation (%)	Height of the seedling when planted in the area of afforestation
Eucalyptus	About 80	About 15 days	About 90	About 2.5 months (about 80%)	25 to 30
Pine	About 60 to 70	About 15 days	About 90	About 3 months (about 80%)	25 to 30
Paraiso	About 30	About 15 days	About 80	About 3 months (about 80%)	35 to 40
Indigenous species	About 70	About 5 to 10 days	About 90	About 2 to 3 months (about 80%)	35 to 40

Source: Interview with MAG-SFN

3-5 Production of Bare Root Seedling

In Paraguay, sometimes it occurs that the planting season is dry without rain, due to continuance of fine weather. Therefore it is sometimes necessary to postpone commencement of planting or to temporarily halt the work after commencement.
For this reason, in case of producing bare root seedling, restrain of growth through limitation of watering or root cutting is not as easy as in producing potted seedling and the seedling may become excessively large due to delay in the time for planting-out. Moreover,

in the event the area of afforestation is far from the seedling nursery, deterioration of the condition of the seedling during the transport process may occur. These factors impact rooting after planting. For this reason, production of seedling using the bare root method is not in general use in Paraguay.
Accordingly, the method of producing seedling using the bare root method will be kept to an explanation of the overview. Establishment of the nursery, arrangement of the area for nursing and treatment of the seeds are as explained in I-1 through I-3.

3-5-1 Method of Production of the Bare Root Seedling

Production of bare root seedling may involve directly seeding the seedling bed and growing the seedling in this bed or seeding the seedling bed first and transplanting to the transplantation bed after germination has occurred. For broadleaf plants with the exception of eucalyptus, the former method is generally used while for eucalyptus and pine, the latter method is used.

3-5-2 Seedling in Seeding Bed

The order of tasks from producing the bed for the bare root seedling to thinning involves the following procedures.

(1) Preparing the bare root seedling bed

A flat bed or framed flat bed as in the production of potted seedling is prepared. When doing this, the same soil as used in the pots is used as dressing soil.

(2) Seeding

a. In the case of eucalyptus, the broadcast sowing method is used. The amount of seed used per square meter should be sufficient for about 250 plants per square meter after germination taking into consideration the germination ratio.

b. In the case of pine, the line sowing method is used. The spacing between ditches should be about 10cm and seeding should be sufficient for about 250 plants per ditch after germination taking into consideration the germination ratio.

c. In the case of paraiso, the line sowing method is used. The spacing between ditches should be about 20cm and seeding should be sufficient for about 120 plants per ditch after germination taking into consideration the germination ratio.

d. Sun cover, watering

After seeding, the bed is immediately covered with soil and watered using a water can. Sun cover is also installed. After all seeds have germinated, the cover is applied only during the day and watering is performed twice a day, once in the morning and once in the early evening.

(3) Thinning out

a. When the young seedlings have reached a height of between 2 and 3cm, thinning out is performed a little at a time on several occasions. The number of plants that should remain is about 120 per square meter for eucalyptus and pine and 60 per square meter for paraiso.

b. The seedlings that should be prioritized for the thinning out process are those that have not grown satisfactorily, that are deformed, injured or have contracted a disease. After this, plants in areas with a high density of germination are targeted for the thinning out process. Upon undertaking the thinning out process, consideration should be given to leaving seedlings that will be targeted for the growth process as uniformly as possible in the seedling bed.

3-5-3 Seedling in a Transplanting Bed

The tasks from preparation of the seeding bed to transplantation involve the following procedures.

(1) Preparation of the seeding bed, etc.

The preparation of the seeding bed, seeding, sun cover, watering and weeding prior to transplantation follow the same procedures as nursing for potted seedling.

(2) Preparing the transplantation bed for the bare root seedling

This involves preparation of the bed for seedling that has been transplanted after germination. The procedures are the same as explained in I-2-2(2).

(3) Transplantation

a. When the germinated young seedling reaches a height of 5 to 7cm, the young seedling is dug out from the seeding bed and transplanted to the bare root seedling bed.

b. Prior to transplantation, the bare root seedling bed is watered and the seedlings are planted in a row spaced about 9cm in the bed.

c. Upon transplantation, the germination bed is watered and the young seedlings removed taking care not to damage the root and transplanted using a stick and ensuring that the roots do not fold. The spacing of planting in the row should be about 7cm. (The density after transplantation is about 120 plants per square meter.)

3-5-4 Sun Cover, Watering

Sun cover and watering of the seeding bed and the transplantation bed for raising the bare root seedling are performed under the following procedures.

a. Until the transplanted seedling takes firm root, sun cover is maintained throughout the day and the bed watered twice a day, once in the morning and once in the early evening. After the seedling takes firm root, the need for the sun cover declines.

b. Thinning out and sun cover and watering after the transplanted seedling reaches a height of 20cm are performed as in the case of the potted seedling.

3-5-5 Root Cutting

In raising seedling in the seeding bed and the transplantation bed for the bare root seedling, root cutting is performed based on the development status of the seedling in order to promote the growth of rootlets. However, this process is not performed in the case of paraiso.

3-5-6 Disease and Pest Control, Additional Manure and Hardening Off

Disease and pest control, additional manure, hardening off, planting in the afforestation area and deferment are as in the case of the potted seedling.
However, the criterion of height of plánturas for planting-out is about 40cm.