

TROPICAL BAMBOOS

Propagation Manual





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PREFACE

This manual is part of INBAR's continuing efforts to produce user-oriented training materials on a range of subjects that would help the sustainable use and management of bamboo resources. With its hands-on rather than academic approach, it is hoped that bamboo users, especially in the developing world, find this a practical tool for bamboo propagation.

INBAR wishes to add here that the information provided in this manual is by no means absolute. Most of the 'hands-on' implementation facts described were taken in the setting of rural China. In other regions of the world there may be differences in the implementation of the propagation methods. However, in general terms INBAR believes that the described methods are applicable in all of its tropical member countries. It is up to the individual user to incorporate his own knowledge and experience while implementing bamboo propagation.

This manual should be considered 'work in progress'. INBAR hopes to incorporate more propagation methods in the near future, such as the 'chusquines method' in South America which is very successful for *Guadua angustifolia*. Moreover, the manual will be thoroughly evaluated in its regions of application, to improve its usability in each of these regions and to keep it up to date with the latest developments.

We are grateful to Daniel Rey Fuentes and the Autonomous Metropolitan University 'Azcapotzalco' in Mexico City for their cooperation in developing a series of bamboo cartoons, some of which displayed in this manual.

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INTRODUCTION

This manual describes seven methods of propagating tropical bamboo species. All information is kept as practical as possible. A lot of pictures have been used, each of which illustrate a separate step in a logical sequence of facts or implementation activities. Substantial text is only used for introductions to the different sections.

Chapter 1 provides a general introduction of the bamboo plant, with a sequence of pictures and descriptions on bamboo morphology and life-cycle. Here some of the terminology is explained that reappears further on in the manual.

Chapter 2 describes several physical characteristics of bamboo culms that change with ageing, and that are therefore useful for estimations of a culm's age. Culm age estimation is required for the implementation of bamboo propagation methods.

Chapter 3 addresses several aspects of bamboo nurseries, important for bamboo growers.

Chapter 4 is the core part of this manual, describing the implementation of seven propagation methods in detail. General information on each of these methods is provided, as well as a 'Step by Step' sequence of pictures, illustrating their implementation. The last section of this chapter shows of list of high-value bamboo 'Priority Species' and their commonly applied propagation methods.

1. BAMBOO MORPHOLOGY

1.1 Introduction

Bamboo is a giant grass, belonging to the same family as rice, wheat, other cereals and sugar cane. The growth vigor of bamboos is unmatched by any other plant in nature; some species reach 40 meters in height and only in a few months time. Other species can grow faster than 1 meter per day. Bamboo is also a very hardy plant and easily propagated.

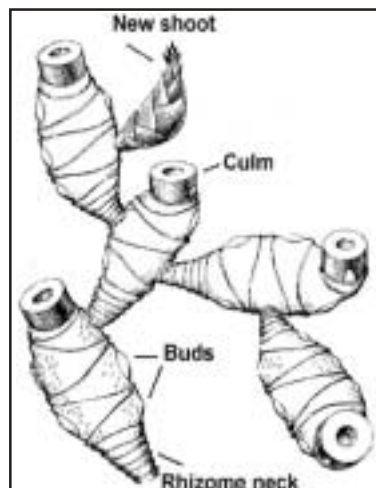
1.2 Bamboos in detail

This section can be considered as an introduction to the following chapters of this manual. It shows the different parts of a bamboo plant and its life-cycle. At the same time certain bamboo terminology is explained, that is mentioned further on.

The information is presented in a sequence of pictures and illustrations, from 1 to 21.



1. Most tropical bamboos are known as 'clumping bamboos', as they grow in clumps.



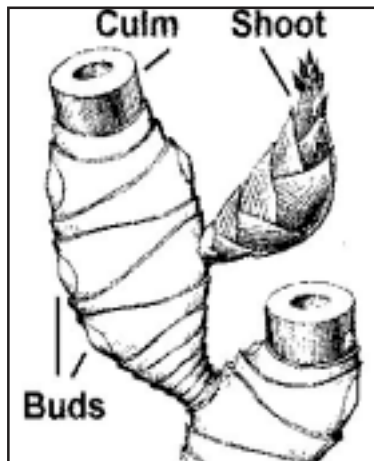
2. This is due to their underground foundation that consists of 'rhizomes'.



3. Rhizomes are linked to each other with a slender part called 'rhizome neck'.



4. Rhizomes are covered with roots for the uptake of nutrients.



5. Rhizomes have buds from where new culms grow, also called 'shoots'.



6. Shoots are covered with protective 'culm sheaths'.



7. Shoots quickly grow into culms that initially keep their sheaths.



8. Bamboo culms have very distinct features, with nodes and internodes.



9. The internode length varies with the culm part and species.



10. The node is where buds are formed.



11. All branches that develop from culm buds are called 'primary branches'.



12. Branching occurs on alternate sides of the culm.



13. Branches too consist of nodes and internodes.



14. Some branches can develop roots or 'rhizomes in the air'.



15. 'Secondary branches develop from buds of primary branches.'



16. Flowering is rare in bamboos and in many species results in death.



17. Bamboo seeds differ with the species, but often look like rice or wheat.



18. Seeds develop into seedlings of this size after one month or so.



19. Seedlings develop into small clumps.



20. Each new shoot is a little bigger than the previous one; the clump is growing... .



21. It may take seven years before mature culms can be harvested form seed.

2. CULM AGE

2.1 Introduction




It is impossible to make a precise estimation of the age of a bamboo culm, unless it was marked after emerging as a shoot. There are no growth rings or any other natural indicators with a hundred percent reliability.




And yet, culm age is an important aspect to be considered by bamboo growers. Harvesting culms that are too young, for example, will affect the regeneration of the clump. And as for propagation methods, they are only applicable for culms of certain age categories.




Fortunately there are a few culm characteristics that change with ageing and those changes are more or less similar for most bamboo species. These characteristics offer some reliability, but bear in mind that they may prove very different when comparing two equally -aged plants of different species. Therefore one should always consider several culm characteristics and not rely on just one.



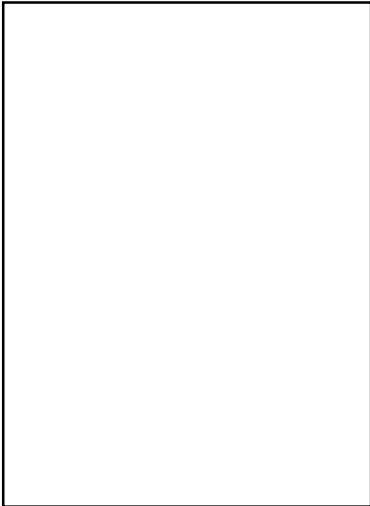
2.2 Culm characteristics




Hereafter six culm characteristics are described, for three different age categories. Pictures were taken in stands of *Dendrocalamus latiflorus*. Other species may show differences in characteristics and in their changes over age categories.

Internode color			
Age category:	< 1 year	1 - 2 years	> 2 years
			
	Emerald or dark green.	Green.	Turning into yellow.

Internode cover			
Age category:	< 1 year	1 - 2 years	> 2 years
			
	Often covered with tiny white hairs, called 'flour'.	'Flour' is falling off.	No 'flour' is left.

Internode epiphytes			
Age category:	< 1 year	1 - 2 years	> 2 years
			
	None.	None.	Lichen and epiphytes are found.

Culm sheaths			
Age category:	< 1 year	1 - 2 years	> 2 years
			
	All or almost all sheaths are kept.	Sheaths are beginning to fall off until none are left.	None are left.
Note: Culms in the center of a clump tend to keep their sheaths longer than culms on the periphery.			

Sheath ring at node			
Age category:	< 1 year	1 - 2 years	> 2 years
			
	Whole sheath ring or part of it is kept.	Remaining part becomes harder.	Remaining part falls off.

Branches

Age category: < 1 year

1 - 2 years

> 2 years



There are no secondary branches. Existing branches feel soft.



Secondary branches start growing. They are lightly colored and not tough.



Branches are becoming tougher and their color is turning into yellow-green.

3 NURSERY ASPECTS

3.1 Introduction

Especially in some Asian countries the supply of bamboo for planting cannot keep up with its demand. In order to alleviate pressure on natural or secondary forests, large quantities of bamboo planting-stock must be produced. Here, bamboo nurseries have an important role to play.

3.2 Bamboo nursery

Hereafter some important nursery aspects are explained, to be considered for successful bamboo propagation.

Site selection

Like in all perennial crops, once established bamboo is difficult to move to another site. The selection of a suitable nursery site is therefore very important. The following points should be considered:



Nursery site...

- Tropical bamboos grow at temperatures ranging from 7 to 40 °C and do not tolerate frost.
- They need at least 1000 millimeters of annual rainfall.
- The nursery should be protected from weather extremes. Presence of trees for shading is a plus.
- The soil should be porous and fertile and provide good drainage. A pH of 5 to 6.5 is best. Saline soils are not suitable.
- The nursery site should be near a water source, a road and also to the planting site.

Seedbed preparation

Seed beds are used for seed germination. They typically measure 1.2 by 12 metres and are raised 15 to 20 centimeters above the ground. The soil must be well drained. Pure sand is ideal but not necessary. A seedbed is prepared as follows:



Seedbeds...

- Dig the soil at least two feet deep and remove large stones and other obstacles to rooting.
- Dig in horticultural sand if the soil is poorly drained.
- Form the soil into raised beds and make a boundary of bricks or wood. Or apply three layers of sand - coarse, medium and fine from bottom to top - each 7 to 10 centimeters thick.
- Level and smoothen the surface.

Sowing

Sowing of the seeds occurs in the seedbed. Germination of fresh seed is higher (70 to 80%) than stored seed. Difuse sunlight or partial shade are also favourable for germination. The following tasks are required:



Station sowing...

- Sow the seeds by covering them with one centimeter of soil. Station sowing (in holes) or sowing in drills is better than broadcast sowing.
- Prevent direct sunlight by providing partial shading.
- Prevent access to the seedbed by birds and rodents.

Propagation bed preparation

A propagation bed is where rooted plants are transplanted to in the nursery for further propagation. The requirements and preparations are similar to the seedbed, except here pure sand cannot be used, as it lacks fertility. The following tasks are required:



Propagation beds...

- Dig the soil at least two feet deep and remove large stones and other obstacles to root development.
- Dig in horticultural sand if the soil is poorly drained.
- Form the soil into raised beds and make a boundary of bricks or wood.

Potting bags preparation

Polyethene potting bags can be used as alternative for seedbed or propagation bed. They are available in different sizes, even to fit cuttings with rooted plantlets attached. The following tasks are required:



Potting bags...

- Prepare a potting bag bed by leveling and firming the soil. Then place woven horticultural matting on top, that will prevent rooting in.
- Prepare a fertile and well draining rooting medium. A mixture of soil and burned organic material is very suitable.
- Fill the bags with the rooting medium and place them on top of the matting.

Continuous nursery activities (1)



Watering...



Fertilizing...



Weeding...

Watering must occur according to the plant's needs. In warm weather water should be applied twice a day. Irrigations systems are costly but can provide exact dosage. A layer of mulch can be applied around the plant base to retain moisture.

Fertilizing is usually applied twice a year - in autumn and spring. During planting a small amount is put on the bottom of the planting hole and then covered with soil. Organic fertilizer is preferred, but otherwise synthetic general purpose fertilizers can be used. Liquid syntetic fertilizers such as Urea can be applied in seedbeds.

Weeding is a regular activity to keep weeds away from seedlings. Bigger clumps don't require weeding.

Continuous nursery activities (2)



Shading...



Disease Control...



Pest Control...

Shading is required when the seedbed receives too much direct sunlight. Seedlings up to 2 years also need protection from direct sun light. Shading can be provided with netting or any available organic material such as bamboo poles and leaves. It is also applied to protect planted cuttings that haven't developed roots yet.

Disease Control mainly consists of identifying and removing infested plants as soon as possible to prevent widespread contamination.

Pest Control involves keeping birds and rodents away from the seedbed. Deep soil cultivation, especially in cold months, helps to reduce certain soil-born pests. Chemical control can also be applied, but may involve health risks or damage to the environment.

4 PROPAGATION METHODS

4.1 Introduction

New bamboo plants can be obtained in two ways; by means of seeds and by cloning. Both are discussed hereafter.

Seed propagation



Bamboo seeds...

This method has a serious limitation, which is unreliable seed availability. This is due to the rather peculiar flowering habits of bamboo. Many species only flower once in 30 to 70 years, other species don't flower at all and many that do die as a consequence. Only few bamboos flower and produce seed frequently.

We refer to section 4.9 for a list of species that can be propagated by seeds. For the majority of species bamboo growers can only rely on cloning methods for propagation.

Cloning

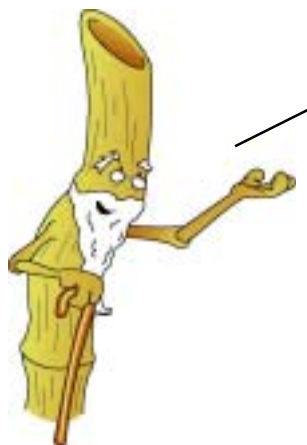


Culm cutting...

In cloning one relies on the bamboo's ability to grow plantlets with roots from rhizome, branch or culm buds. This naturally occurs when plant parts with buds are brought in contact with soil.

The new plants will be exact copies -or clones- of the mother plant. The advantage of cloning is that the selected motherplant's qualities are always present in the offspring.

In addition to the traditional method of 'clump division', several new cloning methods have been developed.



Hereafter six cloning methods as well as seed propagation are described in detail.

4.2 Offsets

4.2.1 General

Method description:	This is a conventional method of clonal propagation and much followed in communities for raising a few clumps in homesteads. A bamboo culm with rhizome attached -called 'offset'- is separated from a clump and transplanted.
Advantages:	With the offset method a bamboo plant is established much quicker than with other methods.
Disadvantages:	Offsets can be bulky and heavy and therefore expensive in labour and transport. Moreover, offsets have a comparatively low survival rate and their availability is limited. Collecting offsets may also cause injury to the clump.
Stages & Planning	
Collecting offsets:	In areas with a pronounced growing season, offsets should be collected just before. Harvesting during the growth season may cause damage to elongated buds.
Planting offsets:	Planting with offsets should be done in a season with sufficient rainfall. Offsets harvested in dry periods should be temporarily kept in a nursery until the next rainy season.
Harvesting mature clumps:	In two years after planting, mature culms can be harvested from the new clump.



The offset method is not very suitable for large-scale plantations !

4.2.2 Offsets - Step by Step



1. Select a 1 to 2 year old culm of a healthy clump.



2. Make a slant cut at 1 to 2.5 meters above the ground.



3. Remove the soil with care from around the rhizome.



4. Check whether the rhizome has healthy buds.



5. Detach the rhizome by cutting the rhizome neck of each connection with other rhizomes.





6. Wrap the offset in moist organic material for transport to the planting site.



7. Dig a planting hole twice as deep as the rhizome.



8. Plant the rhizome and firm in well.



9. Apply mud on the cut end or water it to prevent drying out.



10. Keep the soil moist but not waterlogged.



11. Watch the first new culm growing after three months...

4.3 Ground Layering

4.3.1 General

Method description: In this method a culm is bent down and its buds brought into contact with soil for regeneration.

Advantages: The culm is not separated from the rhizome until the new plantlet has developed its own roots. This may increase success rates.

Disadvantages: The method requires a lot of space and is not suitable for large species or in dense stands.

Stages & Planning

Applying the method: In any season with sufficient rainfall.

Regeneration: After one month the buds grow out into shoots and in the next 3 to 4 months root development takes place.

Availability mature culms: It may take 3 to 4 years before mature culms can be harvested from the new clump.



This method is not suitable for large-scale plantations.

4.3.2 Ground layering - Step by Step



1. Select a 1 to 2 year old culm with healthy buds.



2. Remove the top part of the culm to stimulate bud growth.



3. Trim all lower branches to one internode.



4. Keep a few branches with leaves at the top node.



5. Dig a trench deep enough to cover the culm with 5 to 9 centimeters of soil.



6. Bend the culm down into the trench.



7. Make a cut at the culm base if it does not bend easily.



8. Peg the culm down with a bamboo stake.



9. Bury the culm under 5 to 9 centimeters of soil, but leave the branches sticking out.



10. Apply a layer of mulch and water to keep the soil moist.



11. Check after three months if the roots have developed well.



12. Sever the culm at its base, but continue applying water.

4.4 Air Layering

4.4.1 General

Method description:

In this method a receptacle filled with soil is tied around a branch base so as to induce the development of roots. After root development the branch is planted.

Advantages:

The branch is planted with developed roots which increases success rates. Moreover, the detached branches are easy to handle and there are plenty branches available.

Disadvantages:

The method is labour intensive and only suitable for species with a thick stout branch base.

Stages & Planning**Applying the receptacle:**

Preferably in a wet season, as the rooting medium must be kept moist.

Rooting:

After one month the buds grow out into shoots and in the next 3 to 4 months root development takes place.

Planting:

After the roots have developed the branch is detached from the culm and planted. This should be done in a season with sufficient rainfall.

Availability mature culms:

It may take 3 to 4 years after planting before mature culms can be harvested from the new clump.



This method is very similar to propagating with branch cuttings !

4.4.2 Air Layering - Step by Step



1. Select a 1 year old plant with primary branches that have a swollen base and buds.



2. Bend the culm down and tie its top to a pole for easy reach of the branches.



3. Prune any other branches at the node to one internode.



4. Tie a plastic sheet around the culm and branch base to serve as receptacle.



5. Prepare a rooting medium of equal parts of moss, soil and potting soil.



6. Mix the rooting medium well and soak it with water. Then squeeze until it ceases to drip.



7. Apply the rooting medium at the branch base in the receptacle.



8. Tie the receptacle up with rope, securely but not air-tight.



9. Prune the treated branch to a few internodes.



10. Water the mother plant regularly.



11. Remove the receptacle when the branch has developed roots at its base.



12. Detach the branch from the culm with a sharp saw.



13. Wrap the branch in organic material for transport and keep it wet.



14. Plant the branch in a slanting way with the bud pointing downward. Or place it in a hole with only its tip sticking out.



15. Keep the soil moist but not waterlogged.

4.5 Culm cuttings

4.5.1 General

Method description: In this method new plantlets are grown from buds of culm segments that are buried under ground. These segments may or may not include pruned branches.

Advantages: Culm segments are easy to handle, which reduces labour and transport costs. Moreover, there is usually no shortage of propagation material.

Disadvantages: Species with thin culm walls do not respond well to this method. Moreover, planted segments initially don't have roots, which makes the method risky.

Stages & Planning

Planting: Planting must occur during any season with sufficient rainfall.

Regeneration: Culm segments sprout within a week, but root development takes 45 to 90 days.

Availability mature culms: It may take 3 to 4 years after planting before mature culms can be harvested from the new clump.



This method is very convenient for large-scale plantations !

4.5.2 Culm cuttings - Step by Step



1. Select a 1 to 2 year old culm with healthy buds.



2. Cut the culm down and remove its top part.



3. Prune branches under the first node.



4. Cut the culm into segments that include one or two nodes with healthy buds. More nodes increases success rates, but makes handling more difficult. Keep at least 5 centimeters on either side of the node.





5. Wrap the segments in organic material and wet it for transport to the planting site.



6. Dig planting holes 3 to 6 centimeters deep and 30 centimeters apart. In one-node segments lay the branch and bud upward. Lay two-node segments with their branches sideward.



7. Bury the segments in horizontal position with branches sticking out.



8. Cover the soil with a layer of mulch and keep it wet. Also shading can be provided with bamboo sticks and leaves.

4.6 Branch cuttings

4.6.1 General

Method description: In this method new plantlets are grown from branches that develop natural air roots or rhizomes. Usually this development must be induced in the previous year.

Advantages: This is a very practical method due to ease of handling. Moreover, branches are plentiful and removing them for propagation does not destroy the culm.

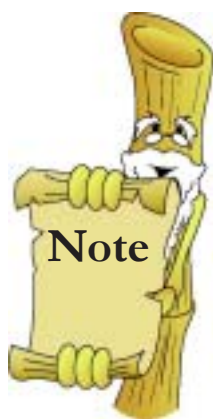
Disadvantages: This method is not suitable for species that have thin branches.

Stages & Planning

Planting: Planting must occur during any season with sufficient rainfall.

Regeneration: The branches usually sprout within a week, but root development takes 1 to 2 months.

Availability mature culms: It may take 3 to 4 years after planting before mature culms can be harvested from the new clump.



This method is very convenient for large-scale plantations !

4.6.2 Branch Cuttings - Stey by Step



1. Select a 1 to 2 year old culm with primary branches that have a swollen base and cut off the culm top. This is done in the previous year to make the branches produce aerial roots or rhizomes.



2. Check the branch base for roots or rhizomes one year after step 1.



3. Prune all branches of selected primary branches.



4. Carefully sever the branches from the culm with a sharp saw.



5. Prune the branches, leave 2 to 6 internodes from the base.



6. Cover the branch base with mud for short-distance transport. For longer distances, wrap it in moist material.





7. Make a planting hole and bury the cutting in it so as to only leave its tip sticking out. Alternatively the cutting may be planted in a slanting way with its base well covered with soil.



8. Apply a layer of mulch on top and keep it moist. Alternatively, provide some shading with bamboo sticks and leaves.

4.7 Whole culm

4.7.1 Whole culm - General

Method description:

In this method new plantlets are grown from buds of a large culm length that is buried under soil. This culm may or may not include pruned branches. Although commonly practised, this is not a very successful method of propagation.

Advantages:

There are no distinct advantages of this method, except that it may be a faster method than using culm segments.

Disadvantages:

Large culm lengths are difficult to handle and the method requires a lot of plant material. Moreover, success rates are relatively low. It takes longer for whole culms to develop roots than it would for culm segments.

Stages & Planning**Planting:**

Planting must occur during any season with sufficient rainfall.

Regeneration:

Sprouting and root development usually take longer than with culm segments.

Availability mature culms:

It may take 3 to 4 years after planting before mature culms can be harvested from the new clump.



Although not very successful, this method is commonly practised for several species.

4.7.2 Whole Culm - Step by Step



1. Select a culm 1 to 2 years old with healthy buds.



2. Dig the culm out and leave on the stump, which absorbs moisture.



3. Measure the culm diameter.



4. Cut the top with a slanting cut and leave 15 nodes for culms up to 15 centimeters diameter. Bigger culms may have 20 nodes or more.



5. Prune all primary branches to one node.



6. Cut a notch in every internode, half way deep and perpendicular to the branch plane.



7. Dig a trench 5 to 10 centimeters deep with a horizontal bottom.



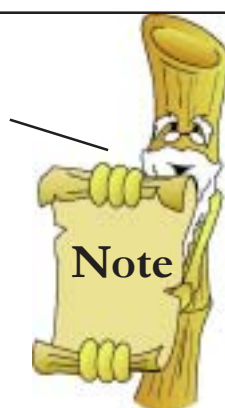
8. Fill the culm cavities with water and bury the culm with the notches pointing upward. Keep the soil moist.

4.8 Seed propagation

4.8.1 General

Method description:	In this method plantlets are raised from seeds that are produced by bamboos after flowering. These plantlets are called 'seedlings'.
Advantages:	In bamboos raised from seed there is no danger that offspring from the same parent plant all die at once after flowering. Moreover, when seed is available, mass propagation can be readily established.
Disadvantages:	Availability of bamboo seed is unreliable and seeds are relatively short-lived and difficult to store. Moreover, it takes a long time before the clump reaches maturity and its quality is not necessarily similar to the parent plant.
Stages & Planning	
Sowing:	Sowing should be done when cloudy skies and sufficient rainfall can be expected.
Transplanting:	If the seedbed consists of pure sand, transplanting into a propagation bed is required as soon as the seeds start germinating. In other cases transplanting may occur after one month.
Dividing up:	Seedling clumps may be divided up into individual plantlets and then transplanted separately for further development. This can be done during transplanting into the propagation bed and every three months from then.
Harvesting mature clumps:	It may take seven years after sowing before mature culms can be harvested from the new clump.

This method is suitable for only a few species that produce seed frequently.



4.8.2 Seed propagation - Step by Step



1. Select a healthy flowering bamboo plant.



2. Spread sheets out under the branches for easy collection.



3. Collect the seeds just before sowing.



4. Remove the chaff from the seed by winnowing.



5. Sow the seeds in holes or drills at least 5 centim. apart.



6. Cover the seeds with 1 centimeter of sand.



7. Apply a layer of mulch on the seedbed and keep it moist.



8. Keep the seedbed weedfree at all times.



9. Check whether the seedlings are developing well.



10. Apply some fertilizer after the seedlings have developed 2 or 3 leaves.



11. Transplant the seedlings into a propagation bed for more space.



12. Keep the seedlings watered and apply fertilizer at planting.



13. Check after six months if the clump has developed well.



14. Carefully divide the clump into separate seedlings.



15. Make sure that each plantlet has healthy roots; remove dead root ends.



16. Transplant the plantlets into a propagation bed.



17. Keep the plants well watered but prevent waterlogging.

4.9 Propagation of Priority Species

Hereafter 19 species and their propagation methods -those described in this manual - are listed. These species were defined as 'Priority Species' by INBAR and IPGRI.

PROPAGATION METHOD:	Offset	Air/ground layering	Culm cuttings	Whole culm	Branch cuttings	Seed
TAXA:						
<i>Bambusa balcooa</i>	●		●	●	●	
<i>Bambusa bambos</i>	●					●
<i>Bambusa blumeana</i>		●	●	●	●	
<i>Bambusa polymorpha</i>	●		●	●	●	●
<i>Bambusa textilis</i>						
<i>Bambusa tulda</i>	●		●	●		●
<i>Bambusa vulgaris</i>	●	●	●	●	●	
<i>Cephalostachyum pergracile</i>	●			●		●
<i>Dendrocalamus asper</i>	●		●	●	●	
<i>Dendrocalamus giganteus</i>	●		●	●		●
<i>Dendrocalamus latiflorus</i>	●		●	●		●
<i>Dendrocalamus strictus</i>	●		●	●		●
<i>Gigantochloa apus</i>	●		●	●	●	●
<i>Gigantochloa levis</i>	●		●			
<i>G. pseudoarundinacea</i>	●		●	●	●	
<i>Guadua angustifolia</i> *						
<i>Melocanna baccifera</i>	●		●	●		
<i>Ochlandra Thw. (Spp.)</i>						●
<i>Thyrsostachys siamensis</i>	●					●

* *Guadua Angustifolia* is native to South America and there mostly propagated with the 'chusquines' method, not described in this manual

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