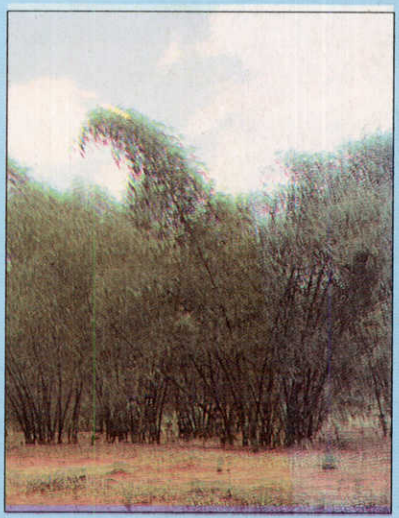
GUIDELINES FOR ESTABLISHMENT AND MANAGING PLANTATIONS OF BAMBOO IN KENYA



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KENYA FORESTRY RESEARCH INSTITUTE
Occasional (Management) Paper No. 1: October, 1995

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ACKNOWLEDGEMENT

The development of bamboo resource in Kenya has been greatly supported by the Government of Kenya and the International Development Research Centre (IDRC), Canada. Some Asian institutions, scientists and the Forest Department of Kenya have collaborated in the procurement of planting materials and maintenance of field research trials.

The handbook has been published in its present form with the support of IDRC. The collaboration, support and financial assistance are all greatly acknowledged.

Guidelines for Managing Bamboo in Plantation

1. INTRODUCTION

The importance of a forest in Kenya is traditionally evaluated from its commercial value, usually in terms of the timber and its contribution to an area, group or the country's income. Rarely do we immediately think of other non-commercial but valuable components of the forest especially services the forest renders to the communities around and the so-called non-wood or minor forest products. In many other parts of tropical Africa, Asia, Central and South America, non-wood forest products have been known to generate substantial foreign exchange in the world market.

Such non-wood products are however little utilized and mostly undeveloped. Since the turn of the century when hardwood logs were leading in local use and exportation, non-wood products were ignored or destroyed during logging operations. In very few areas, these were however gathered for domestic use.

The importance of non-wood forest products and services has changed particularly because of decreased timber yields and an alarming rate of deforestation in the country. The government has focused on formulating new policies that would address the state of low supply of wood products. A ban on logging has been declared in most of the forests in the country and awareness campaigns on the importance of forests and forest conservation have been undertaken particularly through non-governmental organizations. The focus has also shifted to the importance of non-wood products and services and their economic potential as alternative source of the much needed revenue.

Among the most important minor forest products, bamboo has continued to rise in recognition particularly during the last one decade. Locally bamboo is being sought for horticultural flower farming, handicraft, residential fencing and other minor cottage industry products like toothpicks, basket making and match sticks. Bamboo raw materials are, however, scarce due to the current ban on bamboo extraction from public forests. Even if the ban was lifted, the cover of bamboo resource is presently low due to recent excisions of indigenous forests where bamboo was more dominant. This calls for production of raw materials from

farms not only to ensure expanded supply, but also to get the materials nearer to the market yards where handicraft industry is on the increase. Increased availability of materials would also provide for the fast expanding horticultural flower farming.

Bamboo resources in Kenya comprise mainly of one indigenous species, *Arundinaria alpina* (alpine bamboo). The species occurs naturally on the main mountains and highland ranges of Kenya and eastern Africa in general. The species is estimated to cover between 145,000 and 150,000 ha, mainly from 2400 m to about 3400 m above sea level (a.s.l.). With exception of a few clumps of the species left on farms by farmers living around forest areas in the highlands, where the species grow naturally, little cultivation of this species has been done. Such farmers are keen to undertake planting themselves, but face problems with establishment and the lack of effective management interventions.

During the last decade, some research on species selection and investigations on their growth was done mainly by the Kenya Forestry Research Institute (KEFRI) in collaboration with several Asian research and development institutions. This research work has introduced over twenty Asian bamboo species into the country. Half of these are successfully growing in the field under various ecological conditions. Appendix I lists species of bamboo introduced in Kenya. The introduced species are more versatile in their use than the local bamboo and therefore the main interest for their introduction. Farmers, horticultural flower farming companies and Forest Department have expressed great interest in growing these bamboo species on their land. But no harmonized methods have been introduced to ensure that projected outputs are successfully achieved.

Silvicultural management of bamboo crops is heavily based on its growth habits particularly the way the rhizome spreads in the ground. Two main systems of rhizome formation are more common. These include the clump forming bamboos (sympodial system of rhizome) and the stolon spreading bamboos (monopodial system of rhizome) – Fig. 1. While sympodial bamboo remains isolated into clumps, monopodial bamboo spreads taking up a large ground and becomes difficult to identify the source or the parent rhizome. Most of the tropical bamboos are clump forming and only one of the introduced species (*Phyllostachys pubescens*) from sub-temperate China and Japan is monopodial. In natural conditions, the local bamboo (*A. alpina*) may also be confused with the

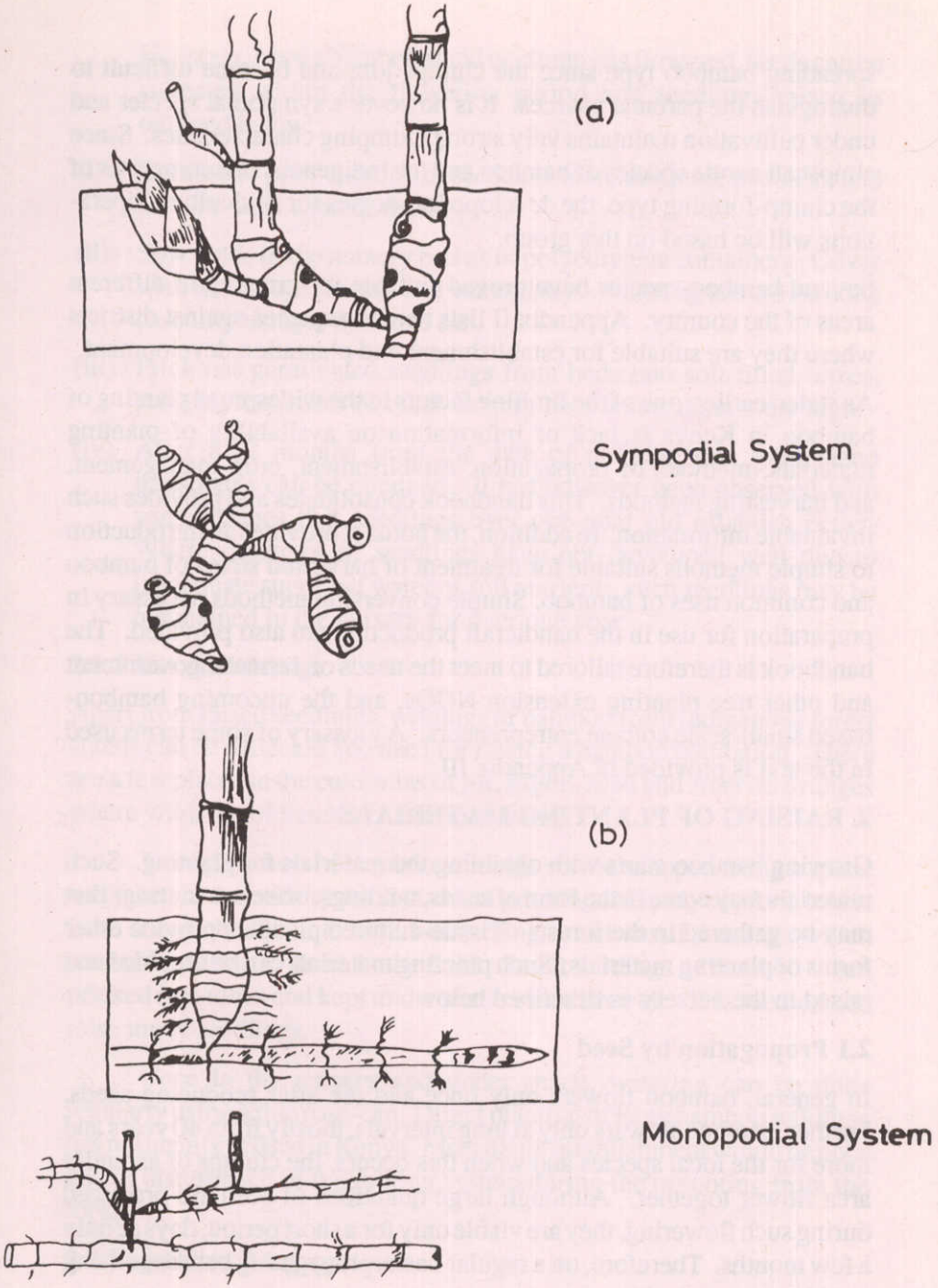


Fig.1: Rhizome formation systems in Sympodial (a) and monopodial (b) bamboos.

spreading bamboo type since the clumps join and become difficult to distinguish the parental sources. It is however a sympodial species and under cultivation maintains very strong clumping characteristics. Since almost all exotic species of bamboo and the indigenous one comprises of the clump-forming type, the developed strategies for silvicultural operations will be based on this group.

Several bamboo species have proved suitable for growing in different areas of the country. Appendix II lists bamboo species against districts where they are suitable for establishment and plantation development.

As stated earlier, one of the limiting factors to the widespread planting of bamboo in Kenya is lack of information on availability of planting materials, methods of propagation, establishment, crop management, and harvesting methods. This handbook consolidates and provides such invaluable information. In addition, the booklet provides an introduction to simple methods suitable for treatment of harvested stems of bamboo and common uses of bamboo. Simple conversion methods necessary in preparation for use in the handicraft production are also provided. The handbook is therefore tailored to meet the needs of farmers, government and other tree planting extension NGOs, and the upcoming bamboo-based small-scale cottage entrepreneurs. A glossary of some terms used in the text is provided in Appendix III.

2. RAISING OF PLANTING MATERIALS

Growing bamboo starts with obtaining the materials for planting. Such materials may come in the form of seeds, wildings, offsets or cuttings that may be gathered in the forests. Tissue-cultured plantlets provide other forms of planting materials. Such planting materials can be obtained and raised in the nursery as described below.

2.1 Propagation by Seed

In general, bamboo flowers only once and die after producing seeds. Further, bamboo flowers only at long intervals, mostly from 40 years and more for the local species and when this occurs, the clumps of an entire area flower together. Although large quantities of seed are produced during such flowering, they are viable only for a short period, days or only a few months. Therefore, on a regular basis, propagating bamboos using seed is not practicable.

However, once a bamboo stand or clump has flowered, seeds can be collected within the flowering period and seedlings raised as outlined below:

(i) Because of poor viability of seed, it is more desirable to collect and sow the seed without delay.

(ii) Sow seeds in the nursery bed or in polyethylene containers. Cover with a thin layer of soil and water daily. Watering should be done carefully using a fine rose can.

(iii) Prick out germinated seedlings from beds into soil filled boxes, polyethylene tubes or other nursery beds when about 3 cm high.

(iv) After 8-12 months from the date of pricking out, good-sized transplants can be obtained. It has however been observed with some species that seedlings over one year old establish better. Where rhizomes of seedlings have not developed well due to inadequate supply of water or soil nutrients, such seedlings may be maintained in the nursery for over one year.

2.1.1 Use of Wildings

Apart from raised seedlings, wildings of bamboo from indigenous forest stands can be collected and used for raising a bamboo plantation. There are a few places in the cold areas of Mt. Elgon, Mau and Aberdare ranges where wildings of bamboo have been found.

Young clusters of bamboo wildings can be scooped using a spade and taken to the nursery for individual pricking into polyethylene tubes. Care should be taken to avoid disturbing intact small wildings which resemble a mass of grass in the field. Small wildings of bamboo when pricked into tubes and kept under shade establish well. This method can raise many seedlings.

Once in the nursery and under shade, watering can be done regularly using a fine rose-can. Direct planting of large bamboo wildings has not been practised in Kenya. Most likely establishment would be poor due to disturbance of the rooting system during the uprooting from the forest.

2.2 Vegetative Propagation

When seeds or wildings are not available, bamboos can be propagated

vegetatively. This offers a better source of planting material. The approach is however limited in space due to difficulties of collecting enough of planting materials. Offsets (rhizome with attached section of stem) are commonly used but extraction of these is laborious. During extraction, damage may also occur to the roots, buds and rhizomes of mother clumps. Offsets are bulky and also difficult to transport. Only small annual planting programmes may therefore be possible when using offset materials.

Use of culm cuttings is a viable alternative and has several advantages. Multiplication of several species is possible by this method. When outplanted, vegetative materials raised from cuttings develop to clumps much faster than offsets and even seedlings. The local species of bamboo (alpine bamboo – *Arundinaria alpina*) and *Oxytenanthera abyssinica* (Appendix I) have however proved difficult, so far, to raise planting materials through cuttings. Both offset and cutting propagation methods are therefore recommended.

2.2.1 Using Culm Cuttings

(i) Good cuttings are obtained from culms of healthy clumps about 2 to 3 years old.

(ii) Two-noded cuttings leaving about 5-7 cm on either side of the nodes are then prepared from the cut culms. A sharp cutting knife or panga is necessary. For bamboos with thin walls, use of a saw is recommended to avoid splitting of the cut ends.

(iii) Some species like *Dendrocalamus hamiltonii* and *Bambusa vulgaris* var. *striata* propagate very well without any further preparation or treatment. These are directly stuck, one node into the soil, in a slanting position or buried in the ground. Rooting from the buried node and sprouting from the node above the ground occur readily. Two node branches of *D. hamiltonii* also root and produce sprouts easily, but these should be stuck into the ground rather than buried.

(iv) For most of the other species (see Appendix I), except for *A. alpina* and *O. abyssinica*, some form of treatment may be necessary to enhance the rate of rooting and sprouting of cuttings. For these, an opening (about 2 cm in length and 1 cm in width) is made in the centre of the internode (Fig. 2a).

(v) The most recommended treatment for root induction is the use of 1-Naphthalene acetic acid (NAA). This is prepared by dissolving 10 g of NAA in 250 ml of ethyl alcohol (95%) in a container and stirring the solution gently. The solution is poured into a clean container and water added to make up 100 litres. Stir thoroughly to mix. The final concentration will be 100 mg/l of water or equivalent 100 parts per million (ppm). This quantity of solution is sufficient to treat 1000 cuttings. Small volumes can be prepared by use of equivalent amount of NAA.

(vi) Pour about 100 ml of the solution into the culm cavity through the opening using a wash bottle or any other convenient apparatus to avoid spillage (Fig. 2 b).

(vii) Then close the hole by wrapping and tying with a polythene strip, ensuring that the wrapper is tight to prevent the solution from leaking (Fig. 2 c).

(viii) The cuttings are placed across the nursery bed, horizontally and, with the opening facing upwards (Fig. 2 d).

(ix) Note that culm cuttings should be treated with NAA as soon as possible (preferably the same day). If not possible due to distance from extraction site, the cuttings may be preserved by keeping in moist sawdust, but only for up to three days.

(x) The prepared culm cuttings are then transferred into a raised 1-m wide nursery bed filled with a mixture of soil and sand (Fig. 2 d). One week prior to planting, the nursery bed is drenched with an effective insecticide (eg. Aldrin or any other) and a fungicide to prevent termite and fungal attack respectively.

2.2.2 Using Offsets

At the onset of rains (usually in April) and just before the new shoot emerges, offsets can be obtained from bamboo stands as outlined below:

(i) Dig out about 30-60 cm below ground for a rhizome of one to two years old culm (for the indigenous bamboo). This can be recognized by the dark green colour and smooth downy stems.

(ii) Once a rhizome is exposed, cut back the aerial culm to 60 cm in length and cut the rhizome off from the parent clump. Avoid

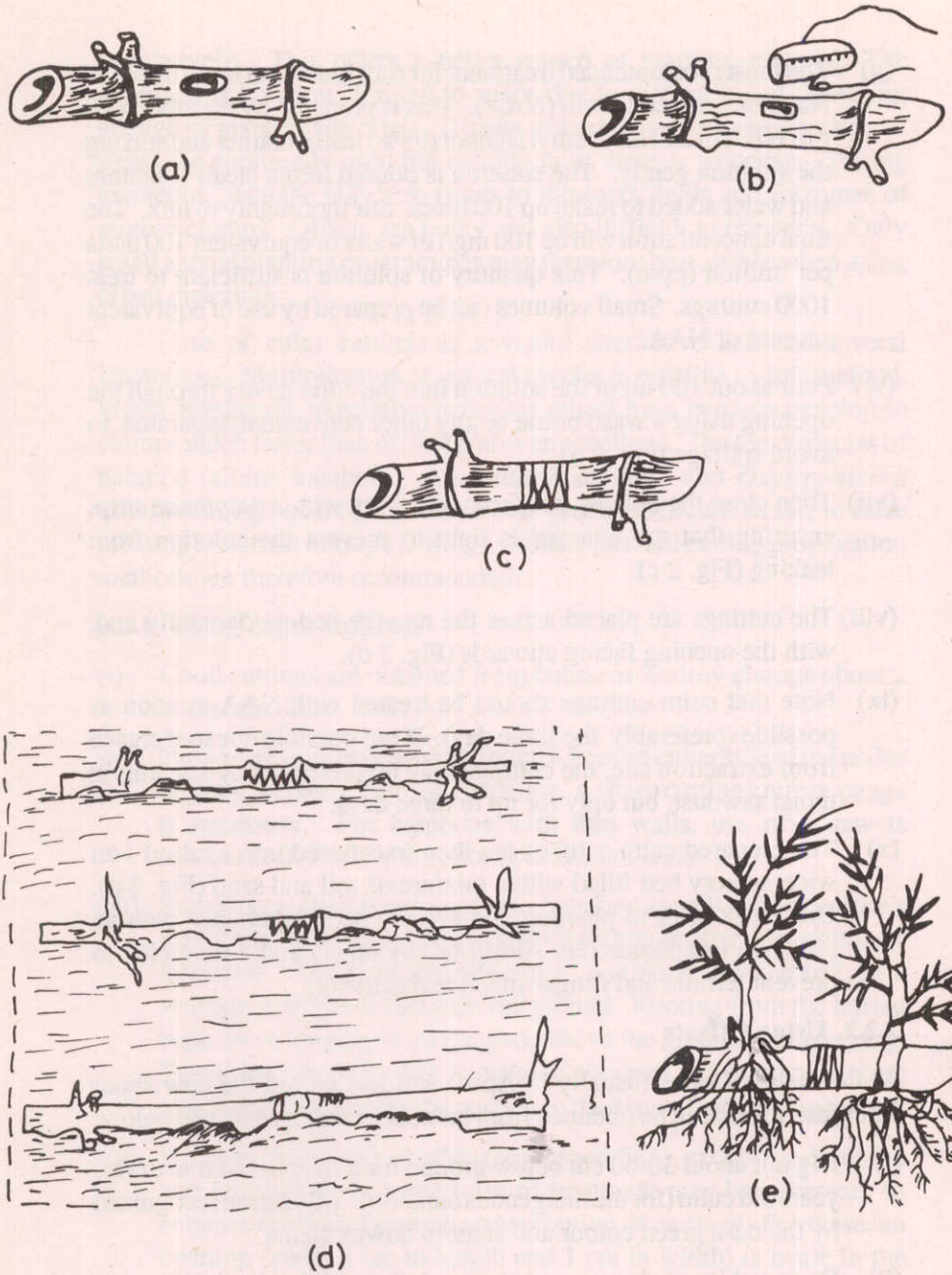


Fig.2: Preparation of culm cuttings (a, b, and c), horizontal placing in beds (d) and rooting and sprouting at nodes (e).

injuring the junction of the culm and rhizome and the underground dormant buds at the base of the culm.

(iii) Extracted offsets should be transported to the planting site without any delay (preferably the same day or the next) and planted immediately.

(iv) Important precautions!

(a) Offsets taken in the late rainy season after the new growth has started usually fail. Therefore, acquire your planting materials as early as possible but timely.

(b) The younger the rhizome, the more the vigour in the buds.

(c) Larger diameter materials are better in establishment and survival.

(d) The larger the aerial culm, the better the survival.

(e) Avoid damaging the junction of the culm and rhizome and the dormant buds.

(f) Do not delay in planting offsets after digging them out. Early planted offsets root easily.

2.2.3 Using Tissue Cultured Plantlets

Tissue culture is an essential method of propagating certain plant species. This method has been successfully employed in mass-production of desirable species of sugarcane, banana, citrus, potato, pyrethrum and flowers in Kenya.

Research in Asian countries on bamboo tissue culture has proved that this method is a very promising alternative source of bamboo planting stock. Tissue culture can therefore greatly enhance seedling production, particularly those that do not fruit easily, and those with difficulties to propagate by cuttings.

Research on tissue culture of local bamboo is proposed to start soon at the Kenya Forestry Research Institute (KEFRI). A small programme of tissue culture of *A. alpina* and *O. abyssinica* was started in 1994 at the Jomo Kenyatta University of Agriculture and Technology in collaboration with KEFRI.

In future, tissue culture method may be widely used for mass-production particularly with large scale horticultural farmers who are

using a lot of bamboo for flower support. More important, uniform production of edible shoots would enhance specific requirements in quality. It is important that farmers should be on the lookout for the development of this technique locally, and those capable could collaborate with the two institutions working on bamboo tissue culture.

2.3 Nursery Techniques and Management

Shading

Whatever planting stock is used (seedlings, wildings, offsets or cuttings) shade must initially be provided to protect them from direct sunlight. The shade, mostly of thatch or any other material could be removed during the onset of cool weather, from late May to August.

Watering

Water is needed by young seedlings and cuttings in beds or polythene tubes. During cold weather, watering may be done only once per day. In the dry season, watering should be done twice a day. As a rule, water the nursery materials regularly.

Treatments

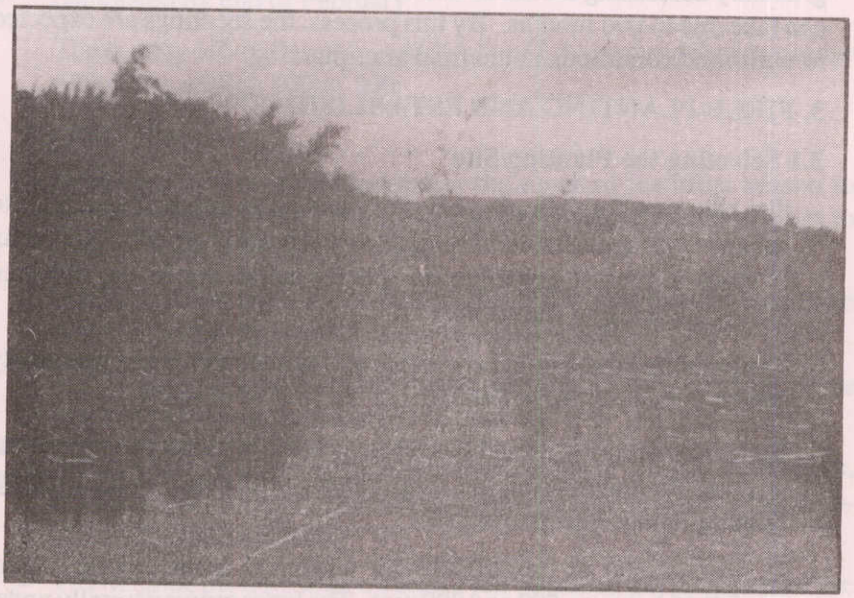
- After one month, it is recommended that sprouts from cuttings are treated with some effective fungicide (e.g., Copper sulphate) to avoid fungal attack.
- If necessary, farmyard manure may be applied to increase the vigour of the sprouts.

Mass Production (Proliferation) of Seedlings

Growth of bamboo is supported by the development of a system of rhizomes. Establishment of planting materials depend very much on how well the rhizome system of a planting material is developed.

Development of the rhizome system starts early in seedlings and buried cuttings, and at some stage in the nursery and can be separated into several individual shoots. Proliferation is the method of separating developed system of rhizome in young nursery materials into many individuals. Such individuals are transplanted into polyethylene tubes that give them 'new' vigour of growth.

A branch cutting nursery of D. Hamilton



Rhizome development of the indigenous A. Alpina

Where procurement of bamboo seed is difficult, available seedlings in the nursery are maintained through proliferation (mass production) while still carrying out annual planting programmes. Cuttings are also proliferated through initial separation of sprouted and rooted nodes (See Fig. 2e), done by cutting at the middle. These are transplanted into separate containers and further proliferation can then be undertaken in the same way as seedlings.

Use fresh potting medium of forest soil or humus and new containers or polyethylene tubes each time in order to rejuvenate growth in separated shoots of seedlings. Multiplication of nursery seedlings should not be carried out at intervals of less than six months. This is to enable adequate development of a critical mass of rhizome system in the containers. Watering in the mornings and afternoons should be strictly followed to allow for fast recovery of the disturbed system of the young roots and rhizomes.

Hardening

Before planting, it is necessary to harden seedlings especially where some shading and frequent watering had been done. This is done by gradually decreasing the shade and watering levels and rates. Hardening can take one to two months. By this process, the seedlings are expected to withstand conditions in the field after planting.

3. FIELD PLANTING AND ESTABLISHMENT

3.1 Selecting the Planting Site

- Site selection for various species of bamboo is important in order to enhance management, field operations and healthy growth. Appendix II gives a general guideline on species suitability in the different ecological areas of the country.
- The planting area should be selected and demarcated early, preferably before January or early February in the year of planting.
- Bamboo prefers loamy and sandy loamy soils, but what is more critical is good drainage since the crop cannot withstand water logging. Sloping land is thus preferable.
- *D. strictus* and *O. abyssinica* can withstand areas having annual rainfall of between 500 and 800 mm. The latter grows naturally under

rainfall of even below this range. For reasonably good growth of the rest of the bamboos, rainfall should preferably be more than 1000 mm. The area of planting should be protected against grazing and fire.

3.2 Site and Ground Preparation

- Planting sites must be cleared of bush, grasses and other unwanted vegetation. Clean cultivation may also be carried out especially where intercropping of bamboo with other crops is to be done.
- After ground clearing, chaining for planting spots is done at a spacing of preferably between 4.5 by 4.5 m to 5 by 5 m for clump forming (sympodial) bamboo. Almost all cultivated species of bamboo in Kenya are of this type.
- Usually holes of about 60 cm square and also 60 cm depth should be dug around each stake in areas of medium to high rainfall. Wider holes of up to 1 metre in diameter are preferred in areas of rainfall less than 1000 mm per year. The latter allows for improved microcatchment. In both cases, the holes must be refilled with soil up to 10 cm below the ground surface. Where necessary mix about 2 kg phosphoric fertilizer or organic manure in the top soil in each pit. Filling should be completed by end of February.
- The density of bamboo plants per hectare (2.5 acres) at the above range of spacing will be 400 to 500.

3.3 Field Planting

- Seedlings should be transported at the onset of the rainy season to ensure good survival. The rains also keep the soil moist enough to provide them with enough water.
- Planting of container or potted transplants from the nursery should be done immediately after the rainy season has set in.
- For offsets removed from the forest, planting must be done the same day with a maximum delay of one night.
- When planting, the potting material (plastic or tin containers, polyethylene bags, etc.) should be removed before placing the seedling in the planting hole.
- The rhizome portion of the offset should be placed 10-20 cm below the ground level and covered with soil.

- After placing the plant (either seedling or offset) in the hole, cover with soil and always lightly press the soil around the plant.
- Where necessary and if financially possible, offsets may be protected against termite attack. The soil returned into the hole is mixed with an anti-termite chemical. Marshal Suscon controlled release-granules are suitable. The chemical has an effect lasting up to three years. Twiga Chemicals Co. Ltd. markets the anti-termite. Due to its non-environmental pollution, it is preferable to the traditional anti-termite chemical formulations.

4. PLANTATION MAINTENANCE AND HARVESTING

Proper maintenance and protection of the plantation is highly important. This involves replanting, plant protection, weeding, general tending and sustainable harvesting of culms (bamboo stems).

4.1 Weeding and Mulching

- In drier areas, with rainfall less than 800 mm, it has been found that mulching around seedlings encourages growth through reduced evaporation of soil water.
- Spot-weeding rids the seedlings of competing weeds. This should be done at a radius of 60 cm around the seedlings after outplanting. Weeding should be regular or as necessary to avoid competition from weeds.
- The soil should be loosened at least three times during the plantation establishment year to improve aeration.

4.2 Replanting

Normally, not all transplanted seedlings and offsets will survive the new environments. Plantations should therefore be visited regularly to check on their survival and replace dead seedlings and offsets. Replanting should be done simultaneously with the first weeding schedule. This is done in the subsequent rain seasons when there is enough moisture until the second year.

4.3 Plant Protection

- Bamboos are palatable to animals and especially in dry grazing areas where goats are left loose. It is necessary to carry out protection against

goats and antelopes using simple sticks. These are stuck in the ground around the seedlings and made to converge above the seedling, forming a conical shape of protection.

- Where browsing may come from large animals, some fencing may be necessary to allow establishment of the bamboo seedlings. Patrolling the area regularly can also protect the plantation from foraging animals.
- Fire is a major hazard to a bamboo plantation especially during the dry season and in drier areas. To safeguard the area, fire breaks should be established. A 10 m wide fire-line is enough to stop fire from spreading into the plantation. In some species, the amount of bamboo litter on the ground is too thick. During the dry seasons, this needs to be reduced by collecting it and thus improving the degree of success in fire control.

4.4 General Tending

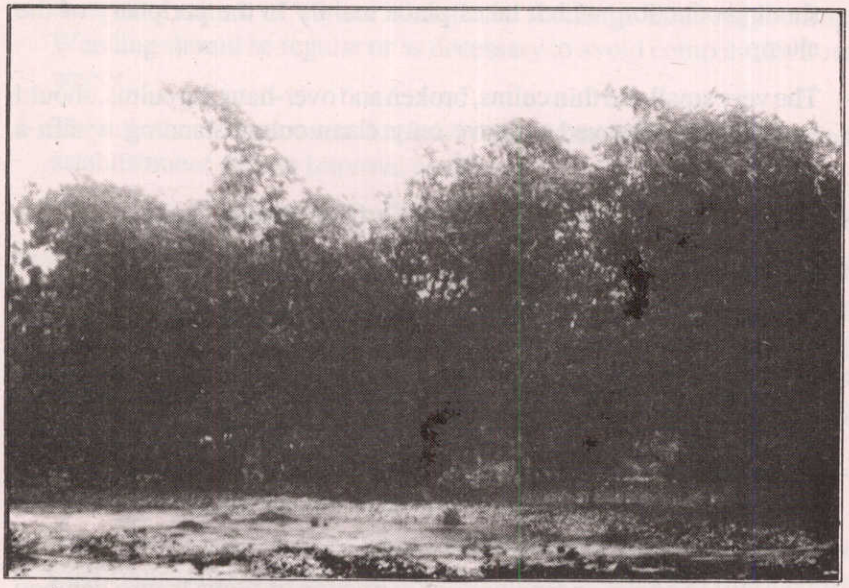
- Depending on the intensity of weed growth, weeding and hoeing may have to be repeated in the second and third year.
- Soil should be heaped around the developing clump to allow and ease shoot production, which takes place mainly in the periphery of the clump.
- The very small and thin culms, broken and over-hanging culms, should be regularly removed to leave only clean culms standing within a clump.

4.5 Harvesting, Cutting Cycles and Cutting Rules

4.5.1 Harvesting

- As stated above, the main bamboo species under cultivation in Kenya are the clumping types. The clumping habit enables the plant to regenerate naturally after harvesting. Harvesting of bamboo is therefore through selection rather than clear-felling.
- The planted area should normally be ready for first harvesting in about six to eight years. Thereafter, cutting of mature stems can be done at intervals of 4 or more years.
- The cutting cycles and methods of extraction of stems from a bamboo

Planting in microcatchments enhances establishment especially in dry sites.



A $2\frac{1}{2}$ years old bamboo plantation at Jilore, Coast.

clump entails an important management system of the entire bamboo plantation. Success or failure of sustainability of crop production will therefore depend on how best stem extractions are carried out.

4.5.2 Cutting Cycles and Methods of Cutting

- After the first cutting in a plantation, subsequent selective extraction of bamboo stems should be done at intervals of 4 years. This cycle of cutting is considered suitable for a number of clumping bamboo species.
- Unless properly managed, clumping bamboos tend to get congested, resulting in deterioration both in quality and quantity. It is difficult to extract bamboo from congested clumps. Some species, if left untended become more congested than others. For example, *Bambusa bambos (B. arundinacea)* is notorious in congestion.
- In a clump, new culms (stems) are normally produced outwards, towards the periphery of the clump and the older stems are left in the centre (Fig. 3).
- Harvesting of bamboo therefore should be from the centre and not at the sides of the clumps. This makes it necessary to maintain clumps in the shape of a horse-shoe, keeping the apex towards the side where the new culms are progressing (Fig. 3 b, c).
- The open end of the horse-shoe (Fig. 3 d) facilitates entry inside the clump for cutting of mature stems.
- The new culms which attain an average height of over 10 m within the first few months, under suitable conditions, are soft and tend to decline unless supported by mature erect stems of earlier years. A few older stems should therefore always be left in the clump after cutting.
- It is necessary that congestion should never be allowed to occur in a clump.

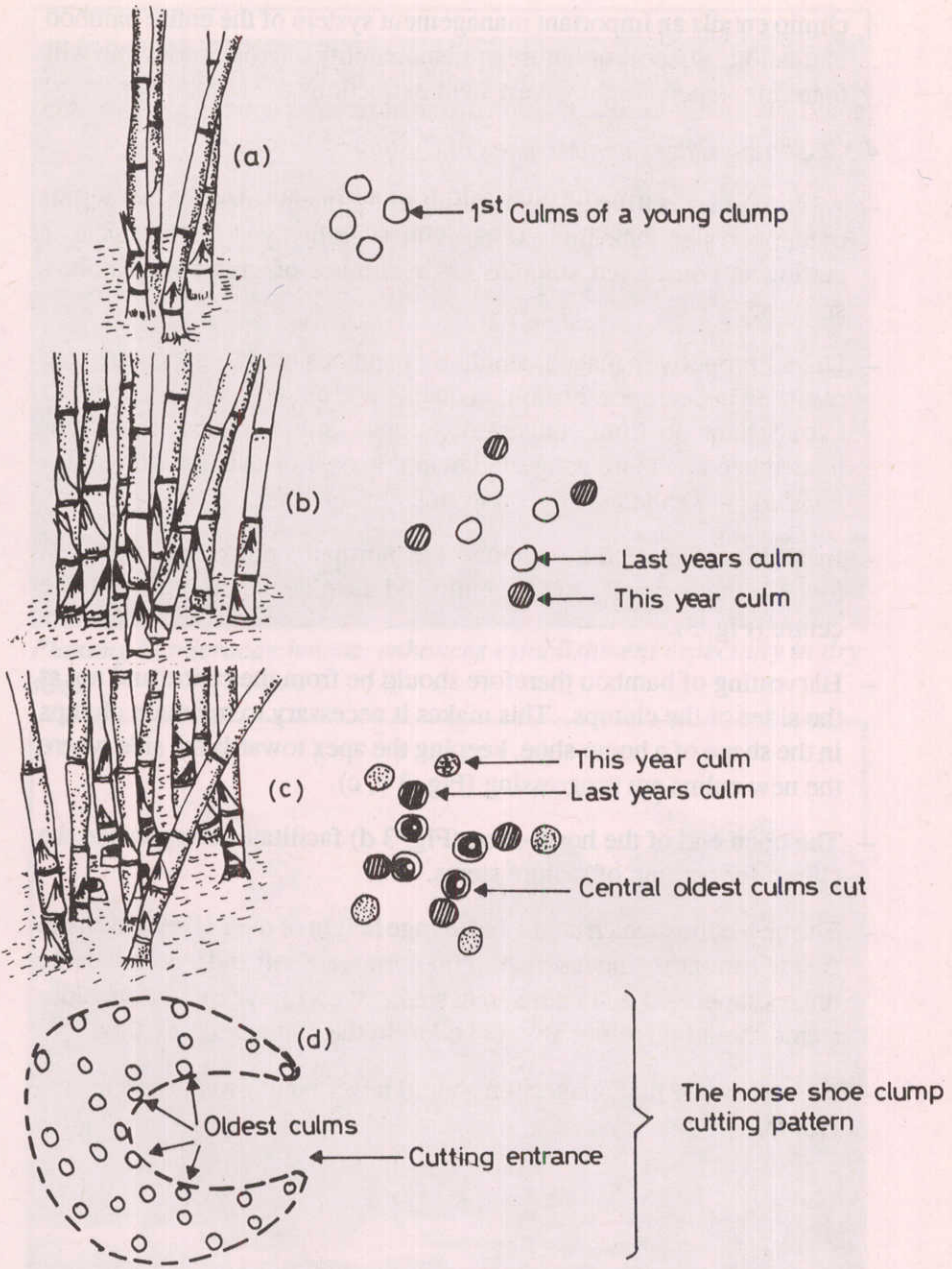


Fig. 3: The development and sustained cutting of a bamboo clump using the horse shoe method.

4.5.3 Cutting Rules

The following bamboo cutting rules are to be followed for a well established bamboo area, taking into consideration what has been stated above:

(i) No bamboos growing on the sides should be cut. Cutting should be restricted to the centre of the clump only.

(ii) All dead and dry culms should be cut and removed.

(iii) All broken, live stems less than 2.5 m in length, should be removed except in clumps containing less than 10 culms. In the latter case, even shorter broken culms may be retained for support of new culms.

(iv) Heavily congested clumps may not be salvaged to productive state and should be clear-felled.

(v) Current year's and one-year old culms should never be cut unless in cases where they are curved and twining around other culms or are infested by disease or insects.

(vi) The number of older culms retained should not be less than the number of current year's culms.

(vii) Rhizomes should not be dug out.

(viii) In order to avoid future congestion, all clumps should be worked, even though they may not produce usable or saleable material.

(ix) Culms should be cut between 15 and 45 cm from the ground, but not below the first prominent node above the ground.

(x) Cutting should be made with a sharp tool-bill-hook, a sharp panga or saw (Fig. 4 a) so that the stump is not split.

(xi) All cutting debris should be collected and removed away from the clump.

(xii) Lopping of bamboos should be prohibited.

(xiii) No cutting should be done during the growing season, i.e. from about April to July and October to November. Cutting should be done only during the dry seasons.

(xiv) In case of sporadic or gregarious flowering, all flowered clumps which have shed their seeds should be clearfelled.

(xv) The areas under bamboo should be strictly fire-protected.

The above cutting rules are important management controls and may be used as a guideline. The rules may be suitably modified for formulating the cutting rules for other introduced species where experiences in their management may not have been locally gained.

4.5.4 Cutting Tools and Extraction

Cutting Tools

- It is necessary that sharp implements are used in order to avoid splitting of stumps and the cut culms. A sharp panga or more preferably a curved saw may be used (Fig. 4 a).

Hauling from Stumpsite

- Extraction roads should be planned during plantation establishment. Fire breaks may also be used for extraction but must be planned in advance.
- Hauling of cut stems should be planned before cutting has started. This is usually ignored when extraction of bamboo is planned for and could result in excessive damage of other vegetation plus excessive soil compaction.
- More important is extraction from areas where terrain is not level and there may be some valleys where cutting is taking place in the valley bottom. In such cases, a tractor fitted with a winch and assisted by a pulley fixed to a tree offers a lot of help (Fig. 4 b). The stems are bundled together, so that these can be pulled easily to the roadside or collection area. Donkey or bull power could also be used instead of the tractor.
- On less difficult terrain, hauling of cut stems and loading onto the lorries can be done easily using human labour.

5. POST - HARVEST TREATMENTS AND USES

5.1 Methods for Protecting Bamboo

Bamboo poles are susceptible to decay and attack by fungi or insects especially powder post beetles. Such attacks give bamboo low natural

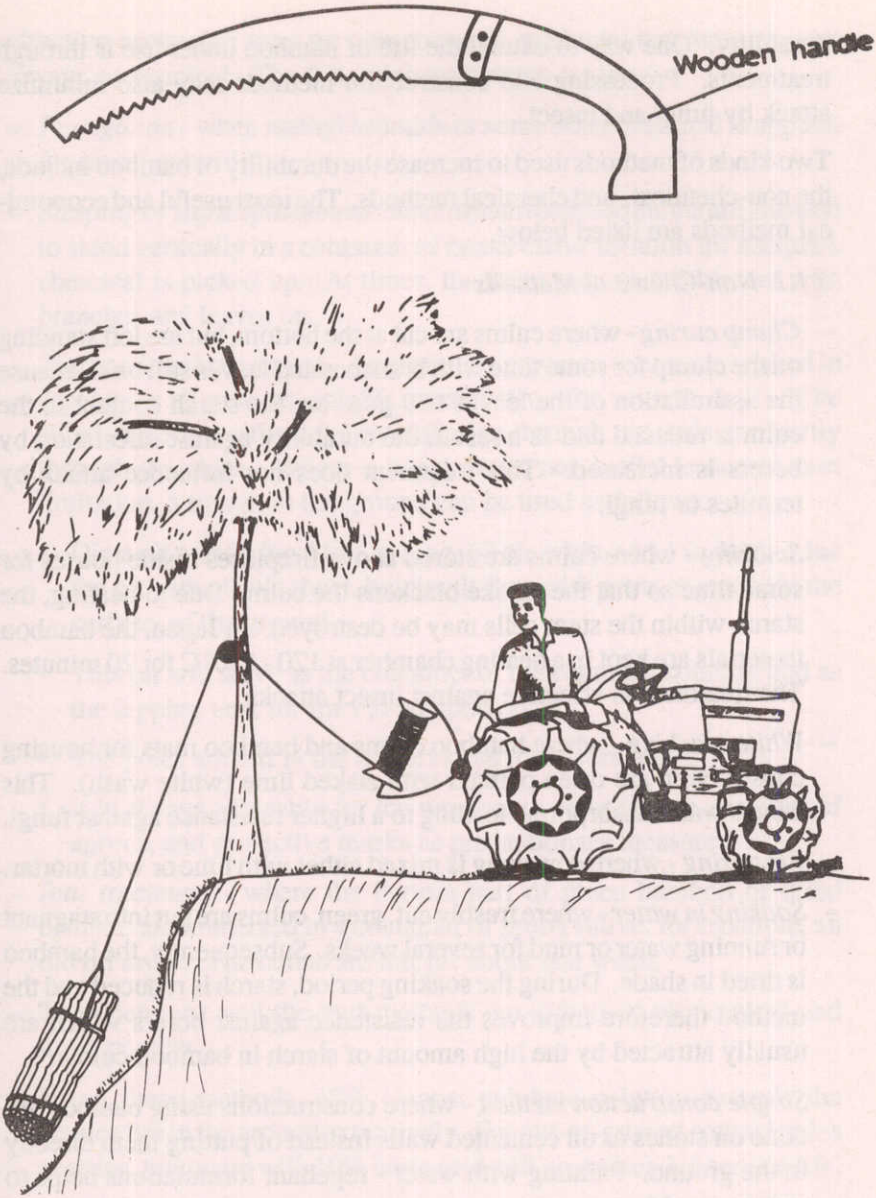


Fig. 4: A suitable curved stem cutting saw (a), and hauling cut bamboo from valleys using a tractor and pulley system (b).

durability. One way to extend the life of bamboo under use is through treatments. Processing and construction methods may also minimize attack by fungi and insect.

Two kinds of methods used to increase the durability of bamboo include, the non-chemical, and chemical methods. The most useful and economical methods are listed below.

5.1.1 Non-Chemical Methods

- *Clump curing* - where culms are cut at the bottom, but are left standing on the clump for some time with branches and leaves still on. Because the assimilation of the leaves still goes on, the starch content in the culm is reduced and as a result, the durability against infestation by borers is increased. This treatment does not influence attack by termites or fungi.
- *Smoking* - where culms are stored above fireplaces inside houses for some time so that the smoke blackens the culm. Due to heating, the starch within the stem cells may be destroyed. In Japan, the bamboo materials are kept in a heating chamber at 120 - 150° C for 20 minutes. The treatment is effective against insect attacks.
- *White-washing* - where bamboo culms and bamboo mats for housing construction are often painted with slaked lime (white wash). This delays water absorption, leading to a higher resistance against fungi.
- *Plastering* - where cow dung is mixed either with lime or with mortar.
- *Soaking in water* - where freshly cut, green, culms are put into stagnant or running water or mud for several weeks. Subsequently, the bamboo is dried in shade. During the soaking period, starch is reduced and the method therefore improves the resistance against borers which are usually attracted by the high amount of starch in bamboo culms.
- *Simple construction method* - where constructions using bamboo are done on stones or on cemented walls instead of putting them directly in the ground. Painting with water - repellant formulations helps to reduce mould.

5.1.2 Chemical Preservative Methods

Using chemicals for preservation of bamboo generally provide more

effective protection than do non-chemical methods, but these are not always economical. The following treatments are used.

- *Fumigation* - when methyl bromide or some other chemical is applied for insect control.
- *Steeping or sap displacement* - where green bamboo culms are allowed to stand vertically in a container of preservative solution till adequate chemical is picked up. At times, the culm may be freshly cut with branches and leaves on.
- *The open-tank treatment* – where culms prepared to size are soaked in a solution of a water soluble preservative for several days. The solution gets into the culm by diffusion through the ends and partly through the sides. Where a big drum is not available due to cost limitation, a trough in the ground can be used as follows:
  - Dig a pit measuring 4 to 5 m long, 60 cm wide, and 1 m deep. Line the pit with plastic sheet, holding it firm with posts or stones at the surface of the ground.
  - This pit will serve as the container of the chemical solution and as the dipping tank for the cut bamboo poles.
  - The poles are left in the preservative for several days.
  - It is always advisable for the workers to wear gloves, waterproof aprons, and protective masks as precautionary measures.
- *Butt treatment* - where the bottom part of green bamboo or dried bamboo are immersed in a container of preservative, for example, an old oil drum. The culms are left for about one week.
- The open-tank and the butt methods are effective, economical and more popular.
- Using these methods, 10% Copper sulphate solution extends the service life in the ground extensively. For out-of-ground contact poles or strips, treatment with 10% boric acid will give extended service life.
- Local farmers have been reported to use old engine oil particularly for green culms. The effectiveness of this method has not been widely reported and documented.

5.2 Current and Potential Uses of Bamboo

Bamboo can be put to many uses most of which have not been locally developed. The following are only a few uses that could locally be developed for the benefit of the farmers.

- *Fencing* is the most common use of bamboo in eastern Africa, particularly for homesteads and farms against animals.
- *Farming* has continued to make use of bamboo particularly in the support of horticultural crops like peas, flowers and for bananas in Uganda. In addition, many farm tools are made from bamboo.
- *Construction and Scaffolding* are important uses of bamboo in the south-eastern Asian region. This has a high potential for use in Kenya and eastern Africa in general, especially with large diameter and strong bamboos. Increasing and developing fast is the use of bamboo in reinforced concrete in buildings of various designs, sizes and uses. For general construction purposes, only mature bamboo culms of more than 3 years old should be used.
- *Handicraft* is an old common use of bamboo, both locally and in particular south-east Asian countries. This makes use of split bamboo. Tea picking, fruit and laundry baskets are common products of handicraft. In other countries, mat making is very common and occupies many communities. Other articles from handicraft activities include toys, ornaments, containers, musical instruments and various industrial products.
- *Shoot production* for food is more common in oriental countries of Asia especially China, Japan, Taiwan and Thailand. Shoot of *A. alpina* is eaten by local people in the Mt. Elgon area of Uganda. Big hotels in Kenya import bamboo shoots as vegetable dishes. Some bamboo species recently introduced in Kenya produce the best shoot quality. These include *Dendrocalamus asper, D. hamiltonii, Thyrsostachys siamensis* and *Bambusa tulda*, among others.
- *Furniture and Particle board* production are an important occupation both by cottage and formal industries in India, Thailand and Philippines. These countries have produced patented designs that are marketed locally as well as outside the countries. These products can be produced by the 'Jua Kali' Sector in Kenya especially as raw materials continue to be produced locally by farmers.

Bamboo provides raw materials for handicraft production and general contruction among other many uses.

- *Pulp and Paper* production using bamboo is an old age occupation in China where paper was produced by hand. Hand-paper production in other Asian countries is still common in India and Nepal. India, China and Philippines produce much of their pulp and paper requirements from bamboo, either alone or blended with other species. The most common blender in India is *Eucalyptus* species.

- *Other common uses* include water pipes and wine production in Tanzania using *A. alpina* and *Oxytenanthera abyssinica* respectively. Local people in East Africa use bamboo for medicine, foliage for domestic animals and water harvesting from roofs of corrugated aluminium sheets.

- In addition to commercial/ benefits, bamboo under natural stands protects soils and is a useful component of water catchment areas. Bamboo can be planted on sloping land to protect soil erosion, to shelter off sewage pools and as ornamental plants at strategic positions in farms or homesteads.

6. CONCLUSION AND RECOMMENDATIONS

- Bamboo remains an important and promising resource in Kenya. It has more potential left for development than many forest resources. As a forest crop, bamboo has a great prospect for advancing social forestry.

- It is necessary for the Forest Service in Kenya to regard bamboo planting as an attraction for rehabilitating degraded lands from high potential to marginal areas. Bamboo root system ties the soil mantle effectively and has the potential to keep exposed and barren mountain-sides under vegetation cover.

- Support for industrial development, especially at cottage level, of bamboo should be genuinely upgraded, focusing on local people and diversification of market opportunities. After all, Kenyans are known for their ingenuity and artistic capabilities, and so the bamboo handi-craft, backyard bench carpentry and decor novelty enterprises may yet be another avenue for displaying local talents.

- To be able to tap the existing potentials for development of bamboo industry, it will be necessary:

  - for the government and NGOs concerned to pay adequate attention to the development and management of the remaining bamboo

resource. Development plan for the resource should be formulated. The speed of replenishing the resource through supporting farmers and through rehabilitation of public forests should be increased;

- to co-ordinate production of bamboo from the public forests to ascertain that sustainable harvesting will be ensured;
- to ensure that research, production and marketing are co-ordinated so that methods of bamboo management, production, utilization and marketing opportunities reach the farmers and the extension forest managers effectively;
- to focus more effort on aggressive dissemination of research results on local and introduced bamboo; and
- a policy statement on the development of non-timber forest products would enhance development of bamboo particularly by local communities.

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APPENDIX I

BAMBOO SPECIES INTRODUCED TO KENYA

Botanical Name	Form of Introduction	Origin
Arundinaria alpina	Offsets and wildings	Kenya
Bambusa vulgaris	Offsets	India
B. vulgaris var. *striata*	Cuttings	Asia
B. bambos (B. arundinacea)	Seed	Thailand and India
B. nutans	Offsets	India
B. thornicornis	Offsets	Asia
B. tulda	Seed	Thailand and India
Cephalostachyum pergracile	Seed	Thailand
Dendrocalamus brandisii	Seed	Thailand
D. hamiltonii	Seed	India
	Cuttings	India
D. membranaceus	Seed	Thailand
D. strictus	Seed	Thailand and India
D. aspera	Offsets	India
Oxytenanthera abyssinica	Seed	Zimbabwe
	Offsets	Zimbabwe
Phyllostachys pubescens	Seed	Japan
P. nigra var. *henonis*	Offsets	Asia
Shibataea ruscifolia (syn. *S. kumasasa*)	Offsets	Asia
Thyrsostachys siamensis	Seed	Thailand

APPENDIX II

BAMBOO SPECIES SUITABLE FOR PLANTING IN DIFFERENT AREAS

District	Suitable Bamboo Species	Source of Planting Materials
Kwale and Kilifi	*Bambusa bambos* (*B. arundinacea*)	Jilore, Gede and Kwale Forest Stations (for all)
	B. tulda	
	Dendrocalamus brandisii	
	D. aspera	
	D. hamiltonii	
	D. strictus	
	D. membranaceus	
	Oxytenanthera abyssinica	
	Thyrsostachys siamensis	
Central Province Districts (high to medium rainfall)	*Arundinaria alpina*	– KEFRI, Muguga
	B. vulgaris	– Aberdares range (***A. alpina***)
	B. vulgaris var. *striata*	– Mt. Kenya (***A. alpina***)
	D. brandisii	
	D. hamiltonii	
	D. aspera	
	O. abyssinica	
Kakamega, Siaya, Vihiga	*B. bambos* (*B. arundinacea*)	– Kakamega Forest Station
	B. brandisii	– Siaya and Vihiga District Forest offices.
	B. tulda	
	B. vulgaris var. *striata*	
	D. hamiltonii	
	D. membranaceus	
	D. strictus	
	D. aspera	
	T. siamensis	
Trans Nzoia highlands	*A. alpina*	– KEFRI, Muguga
	D. aspera	– Kaptagat and Penon Forests
Medium to low rainfall Districts (Ecozone III and semi-arid)	*D. hamiltonii*	– KEFRI, Muguga
	D. strictus	– Gede, Coast
	O. abyssinica	– Kakamega Forest Station
		– Vihiga and Siaya District Forest Offices.

APPENDIX III

A GLOSSARY OF SOME TERMS USED IN THE TEXT

Clump - A cluster or group of stems of bamboo growing from a common underground rhizome system

Culm - A stem of bamboo plant

Cutting cycle - Period between stem cutting or harvest from a clump and the next time cutting is done in the same clump or bamboo stand. Cutting cycles are series of cuttings or harvest taking place in a regularly repeated order.

Fine Rose can - A can usually with a handle and an arm fitted with a rose-shaped cover at the end, with fine holes for watering seedlings.

Monopodial Bamboo - Type of bamboo formation that spreads by underground rhizomes or stolons. Most of monopodial type of bamboos are found in the temperate climatic conditions.

Mulching - Protective covering of leaves spread over the roots of nursery or planted seedlings to retain moisture or smother weeds.

Offset - A dug out rhizome with a short portion of a culm (about 50 cm long) attached.

Sympodial Bamboo - Type of bamboo formation that displays distinct clumping in their development and growth. Sympodial bamboos grow mainly in the tropical climatic conditions.

Plantlets - Smalls plants that develop from mass of cells (callus) of plant parts being used in mass propagation of bamboo through tissue culture technique.

Rhizome - Thick, horizontal stem of bamboo just below the ground, from which new shoots and roots grow.

Plant Tissue culture - Several techniques that together enable the nurturing of a plant organ, tissue, cells or even cells without walls in a controlled nutrient medium. The technique is useful in mass propagation of plants.

Wildings - Seedlings germinated in the wild under natural conditions after bamboo plant has flowered and produced seed.