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Cottage Industry Manuals

Raw Materials and Tools for Bamboo Applications

EASTERN AFRICA BAMBOO PROJECT

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ETHIOPIA

Ministry of Agriculture and Rural Development
Federal Micro and Small Enterprise
Development Agency

KENYA

Kenya Forestry Research Institute

COTTAGE INDUSTRY MANUALS

RAW MATERIALS AND TOOLS FOR WOVEN BAMBOO APPLICATIONS

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I. THE GROWTH OF BAMBOO

Every type of bamboo product that is manufactured with a view towards quality and durability makes use of raw materials with distinct material and mechanical properties that are inextricably related to the biology of bamboo. Some general observations on the growth of bamboo are therefore noteworthy.

A. *Bamboo is a Grass*

Bamboo is a member of the grass family. There are over 1200 bamboo species. Many bamboos are herbaceous and resemble other shrubby plants of the grass family. The most common bamboos are timber species which resemble trees in some ways. However, bamboos are not trees; they share the biological features of other grasses, most notably their jointed stems. Joints or nodes are apparent in bamboo poles or culms, but are characteristic features throughout the plant, including the underground rhizomes and the branches.

B. *Two Main Bamboo Groups*

Most bamboo species fall within 2 groups with distinct rhizome systems:

1. *Clumping bamboos:*

This group of bamboo species has pachymorph or clump forming rhizomes. The bamboo plants of this group grow in clumps. Depending on the species, the clumps form loose clumps with a relatively wide space between culms. Other species form tight or densely tufted clumps, wherein the culms are very close to each other. Some bamboos with tight clumps are almost impenetrable, which makes management and harvesting very laborious.

2. *Running bamboos:*

This group of bamboo species has leptomorph or spreading rhizomes. Leptomorph rhizome systems stretch and expand to form a complex underground network, which leads to the formation of a grove made up of widely spaced culms. Unlike clumping bamboos, the culms of running

bamboos species resemble individual trees, but as mentioned they are grasses, and the individual culms are actually linked together through the underground rhizome. Spreading rhizome systems can extend across wide areas, and groves can expand to become large forests.

C. Bamboo Culms

Bamboo culms are aerial parts of the bamboo plant which develop and grow from the underground rhizome system. When a bamboo shoot emerges from the soil, it develops into a culm by elongating vertically towards its maximum height. This process of vertical growth is fully completed in one growing season, and lasts between 3 to 6 months depending on the species. Unlike trees, individual bamboo culms do not grow diametrically or become thicker over time. The diameter of the bamboo culm remains unchanged throughout its lifespan.

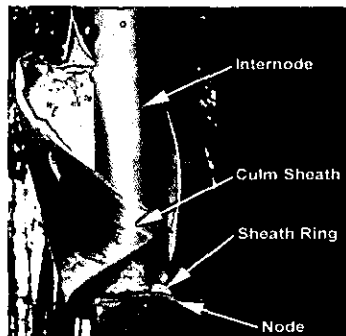


D. Nodes and the internodes of Culms

Internodes are the separate sections of the culm.

A node is the connecting ring of on each section of the culm that separates one internode from another.

Nodes are present in rhizomes and new shoots of the bamboo plant.



The major function of internodes is to give horizontal strength to the culm and prevent it from deforming and cracking. When new shoots emerge during the growing season, the internodes sections will elongate

from the nodes of the shoot. Sometimes the internodes can elongate 3-5 cm in 24 hours.

There is a sheath ring on each node. That is where bamboo sheathes grow in the first year. After the bamboo sheathes drop off, branches will start to grow on the culm.

E. Lifespan of Culms

The lifespan of a standing bamboo culm is about 10 years, but this figure may be more or less depending on the species. Individual culms undergo a gradual process of development. As a culm matures, it becomes harder and acquires the properties of timber. But with the passage of years, the standing culm gradually loses its strength and eventually dies. Culms of some species die within 5 years after they have reached maturity, while others enjoy greater longevity.

F. Lifespan of the Bamboo Plant

The maturity and lifespan of individual culms should not be confused with the maturity and lifetime of the bamboo plant. This biological feature of bamboo is important. The bamboo plant is sustained by its rhizome system. When old culms die, the bamboo plant will continue to live on, expand, and regenerate new culms. The natural lifespan of the bamboo plant is usually more than 50 years for many species, and over a hundred years for many others.

G. Growth and Maturity of the Bamboo Plant

When a bamboo seed germinates naturally or when a young bamboo plantlet is cultivated (e.g. a *Bambusa* species which has pachymorph rhizomes), the rhizomes develop and generate new shoots, leading to the formation of a clump with young and very thin culms. Each year, with the progressive growth and development of the rhizome system, shoots of an ever larger will emerge from the soil. Usually within 4 to 5 years, the emerging shoots will attain the maximum size and diameter typical of the species, and the clump will include several new culms with a large diameter. In subsequent years, the diameter and size of new

culms will not increase. It is at this stage in time when it can be said that the clump or grove has reached maturity.

H. Gregarious Flowering

The life of a clump or grove expires when mass or gregarious flowering occurs. Gregarious flowering occurs periodically for many bamboo species. Some species flower every 30 years, others every 50 years, while others every 100 years or more. For some species, gregarious flowering has never been observed. The underlying cause of the phenomenon of gregarious flowering of bamboos remains a mystery to scientists. It is however known to occur in temporal cycles with an almost predictable frequency for some bamboo species. Gregarious flowering affects an entire genotype or variety of the species all over the world. The flowering process is gradual and it may take several years before the variety or genotype of the species dies. With the onset of gregarious flowering, seeds are generated and dispersed on the land. The entire rhizome system and all the standing culms of the species die and decompose. The fertile seeds that germinate give way to a new generation of bamboo. It should be stressed that the gregarious flowering process is specific to a genotypic variety of a species. In other words, in a forest or plantation with a diversity of bamboos, only the genotypes that are flowering will die.

I. Sporadic Flowering

Not all flowering of bamboos is gregarious, and flowering does not always result in the death of the plant. Some bamboos flower sporadically, sometimes in large areas, but occasionally in individual clumps. Sporadic flowering may occur when the plants are under stress, but its causes are not yet fully understood by scientists. The eventual flowering and generation of seed seems to be a biological defense mechanism to secure the survival of the species. When sporadic flowering occurs, the plants may recover and continue to live on.

II. MATERIAL PROPERTIES OF CULMS

The material properties of the bamboo culm develop and change year after year. Knowledge of the material properties of bamboo, particularly in relation to the age and parts of the culm, is essential for selecting raw materials for bamboo products.

A. New Culms

New culms (i.e. younger than 1 year old) are soft and their moisture content is high. Their fibers are tender and they lack the sturdiness of older culms.

B. Lignification

As a culm ages, it undergoes a lignification process, which involves the thickening of plant cell walls through the deposition of lignin, making the bamboo harder and more woody.

C. Maturity

The 'mature age' of a bamboo culm can be defined as the point in time when the culm has ripened and reached the vital peak of its development in terms of its species specific biological, chemical, and mechanical properties. The culms of many small bamboo species are fully mature when they are 2 years old. The culms of mid to large timber bamboos generally mature when they are 3-4 years old. The culms of some giant bamboo species mature within 4 to 5 years.

D. Deterioration

In the years following maturity, the bamboo culm gradually becomes old and weak. Culms that are not harvested will eventually dry out, die, and decompose.

As a general rule, the vitality, quality, and strength of culms deteriorate substantially 3 years after they reach their peak of maturity.

E. Properties along the length of the culm

The properties of culm differ in varying degrees along its length. In particular, the fibers of the lower part of the bamboo culm are generally more tender, flexible, and pliable compared to fibers in the higher section or tip.

The base and middle sections of the culm are closer to the roots and rhizomes which supply food and energy to the whole plant. Moisture and nutrition follows an upward path along the cells of the culm, diverting throughout the branches and foliage, and extending towards the tip of the culm. Accordingly, there is greater moisture in the cells and fibers of the lower and middle culm sections, than in the upper sections.

The upper portion and tip of the culm receives direct sunlight and more heat in comparison to the lower portion, which is shaded by the canopy of foliage. This component of solar radiation also contributes to the properties of fibers at various levels of a culm's height.

III. SELECTION OF BAMBOO RAW MATERIALS

The selection of bamboo raw materials is very important for high quality woven products. Culm length, age, and the growing environment of bamboos are the main criteria for selecting raw materials. Sometimes it may take 2 to 3 days to find the appropriate materials for a specific type of woven bamboo product.

A. Properties for Specific Applications

The raw material required depends greatly on the intended application and desired characteristics of the product that will be manufactured. For instance:

- New culms (i.e., younger than 1 year old), which have very soft and flexible fibers, can be used as finishing strips for weaving and for making woven bamboo toys.

- Fibers from 1 year old culms, which are quite tender, are the best materials for plain woven pictures and calligraphies.
- For plain bamboo weaving, the base and middle portion of the culms are ideal materials, since they have more tender fibers than upper section of the culm.
- 3 to 4 year old culms are ideal for bamboo furniture making.

B. Determining the Age of Bamboo Culms

Identifying the age of bamboo culms is an essential skill in the raw material selection. There are 3 methods to identify the age of culms.

1. Color of the Culm

Identifying the age of bamboo culms by their color is possible with new and young culms, but is increasingly difficult for older culms. One year old culms generally have a distinctive sheen, which is typical for green, yellow, and black bamboo varieties. Bamboos with green culms generally have a dark green color when they are 1 year old, but as the culms age, their color gradually fades and becomes murky.



Notice the difference in color of 1, 2, 3, and 4 years old culms.

For most species, it is difficult to distinguish 2 and 3 year old culms by their color.

New culms of black bamboo species (e.g. *Bambusa lako*, *Phyllostachys nigra*, *Gigantochloa atrovioleacea*) emerge with green culms, which gradually darken after the first year. If the species is known to be a black species, then green culms can be identified as being 1 year old; however, as the culms darken, their age is more difficult to ascertain. Black culms tend to become very dark during the third year, so if they are not very dark, it is likely that they are about 2 years old, but there is no certainty because the colors of bamboo species can vary according to their location.

Differences in edaphic and climatic conditions can have a significant impact on the appearance of the same species in different locations. In effect, ascertaining the age of culms by means of color is not a very reliable method unless one has carefully observed the pattern of color changes of culms of a species, year after year, in a specific environment or location.

At best, observing the color of culms can provide clues to estimate whether the culm is young, mature, old, but such assessments may be off the mark by several years.

2. Branch development and ramification

Observing the development of branches on the culms can assist in identifying the age of young culms. However, it is not a very reliable method for determining the precise age of culms. The method of observing the branch development and ramification in subsequent years requires good knowledge about the morphological characteristics of the bamboo species or genus.

Most bamboo species develop primary branches during their first year. In the case of bamboo belonging to the *Phyllostachys* genus, a primary branch is formed at each node, alternating in opposite directions, from one node to the next one. In subsequent years, ramification occurs from buds in the primary branches, creating new axial branches with buds that may either remain dormant or ramify into a new branch axis, usually in the following year. The number of axial ramifications on a

branch can therefore provide an indication of the age of the culm for some *Phyllostachys* species. However, since species tend to develop differently from each other in diverse locations, it can never be ascertained whether secondary ramifications actually occurred in the second year, or even if a further tertiary ramification occurred during the same growing season.

In order to use this method, it is therefore necessary to observe and record the behavior of branch ramification of the culms of a particular species in a precise location. Only with such information at hand, will it be possible for someone to gauge the age of the culm, but even then, a high probability of accuracy cannot be assured.



Culms of *Bambusa cerosissima*



Branches of the *Neosinocalamus affinis*

Try to identify the age of the culms in the pictures above.

3. Marking Culms

In China, where people have gained a mastery of bamboo, the difficulty of determining the age of culms by their color or branch ramifications, has led to the implementation of a very reliable method which involves marking each new culm. The method is laborious since it involves inspection of an entire plantation or forest and marking each new culm with code indicating the year of emergence. For example, the culms that emerge in year 2007 can be marked with "07" using indelible ink or paint.

It should be noted however that this method is practical with *leptomorph* bamboos like Moso, but is much more difficult with *pachymorph* bamboos since new culms may not be easily accessible within the clump.

IV. HARVESTING AND POST HARVEST CARE

As mentioned above, each bamboo application requires materials with specific characteristics which are related to the age of the culm and to the part of the culm.

A. Harvesting

Before harvesting, it is very important to select the culms suitable to the intended application.

For bamboo weaving, 1 year old culms should be selected. The thickness of the culm wall of the species is important because it will determine the number of layers and strips that can be obtained from a culm. On the other hand, if the culm is too strong, it will be difficult to strip the bamboo. It is therefore important to select the species for harvesting very carefully.

For making bamboo furniture, select culms that are mature (3-4 years old). The choice of species for furniture making is very important because the culms walls should have a minimum diameter of 3 cm with culm walls of at least 5 mm. The diameter of the culm and the thickness of the culm walls may be larger, depending on the type of furniture. As

a rule, very small and thin culms are not suitable for furniture making. If the culms are too thin, the material will not have the strength to support weight, as required by the type of furniture. Moderately large to large pachymorph and leptomorph bamboo species are suitable for making furniture. In China, *Phyllostachys pubescens* (Moso bamboo) is used for making furniture, but many other pachymorph species are also suitable. In Eastern Africa, *Yushania alpina* is used for making furniture. Giant species of the *Dendrocalamus* genera are also favorite species for making furniture with large and thick poles.

The time of harvesting is very important. Bamboos grow during the rainy season. During the season of growth, the culms have very high moisture content and also a high starch content which provides nutrients to the plant and supports its growth and expansion. Bamboo poles should therefore never be harvested during the rainy or growing season. They should be harvested during the dry or winter season. In other words, bamboo culms should be harvested at the time of the year when the moisture content and starch content of the culms is lowest. The period of harvesting varies from location to location. Generally, in the northern hemisphere, the winter (dry) months are from November to February. In the Southern Hemisphere, the dry months are between May and August. Note that the climate in each region varies depending on its latitude, so it is important to be aware of climatic patterns of the specific region. In many areas, for example, along equatorial zones, there are short and long rainy seasons, and each bamboo species behaves differently according to the climatic patterns. As a rule, only harvest the culms during the driest periods of the year.

Culms should be harvested selectively, according to the requirements of the product and industry. The culms should be cut just above the first or second node, or around 15 to 20 cm above the ground.

After cutting down bamboo culms, they will have to be dragged or carried through the spaces between the clumps to a nearby area where initial post harvest treatment can begin.

B. Removal of Branches

The first step after harvesting is to remove all the branches of the culm.

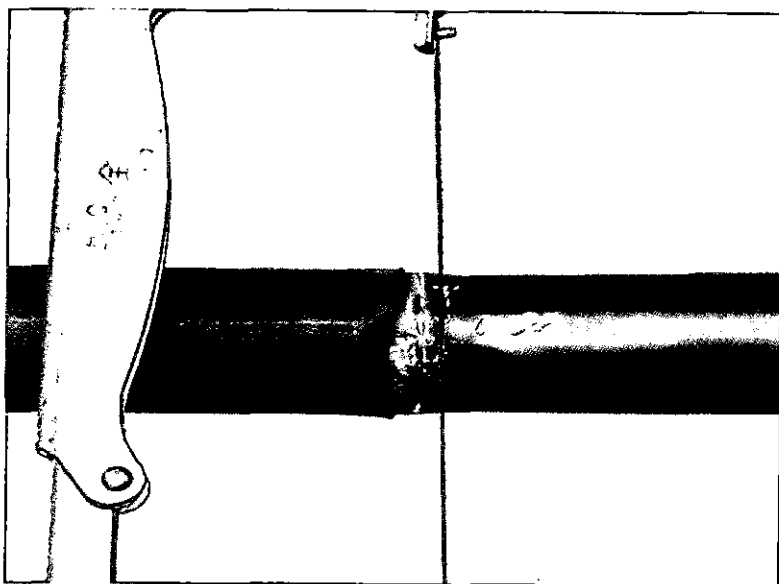
Branches should be cautiously removed in order to avoid damaging the culm.

The outer layer of skin of the culm should be protected very well to avoid scratching them.

Once the culm is stripped of its branches and foliage, the culm should be cut into sections in order to facilitate transport to the area where processing will take place.

C. Cutting the culm into sections

Cutting the culm into short sections that are easy to carry is an essential step in order to prevent the internodes from cracking or being damaged during transport. When cut into short sections, the material can be packed and bundled in order to maintain their good quality for processing.

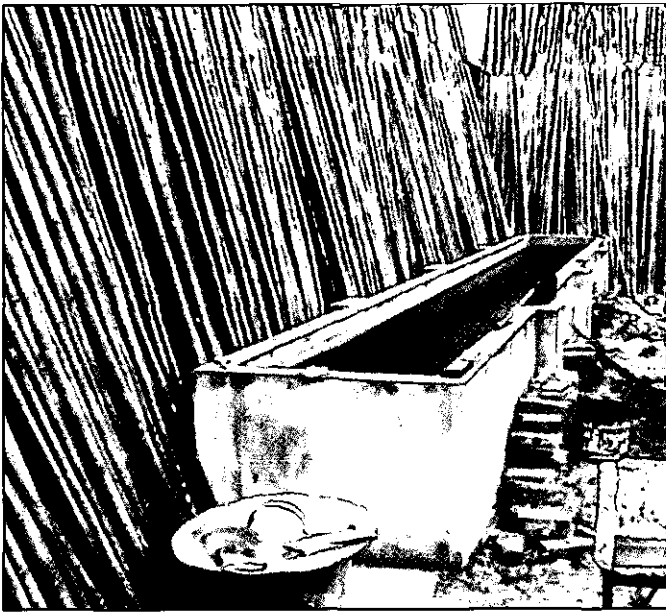


To separate bamboo culms into sections, it is necessary to place the saw 0.5 cm away from the node and cut parallel to the node. A straight cross section cut will enable one to see the actual thickness of the culm wall.

D. Preservation

1. Soaking Method

One common and simple method of preserving bamboo is to allow the culms to soak in water for 15 to 30 days. Soaking makes the culms more subtle and increases their resistance to cracking when they are dry. Soaking in water however does not provide any defense against fungal and/or attacks by pests such as borers.



A preservation pool for bamboo culms.

To increase the resistance of the culms to pests and fungal attack, it is preferable to allow them to soak in the culms using a pool with a chemical agent. The pool that is 8-10 meters long, 1-2 meters wide, with a depth of 1 meter is good for long culms. The size of the pool will depend on the length and size of the culms. Smaller pools are useful for short bamboos or for culms that have been divided into short sections.

One possibility for the soaking method of preservation is to mix potash lye to the water using a proportion of 1:200.

Alternatively, the culms can be protected by adding boric acid to the water in the pool using a proportion of 1:600.

After the soaking process, allow the bamboos to air dry in a shaded area. It is important to remember that the bamboo may crack if the drying process is too rapid. So protect the culms from heat and direct sunshine while they are drying.

2. Smoking and Spraying

Another method of preserving bamboo is by smoking the culms in a sealed chamber. The material of the chamber can vary; plastic sheets may be used. In some areas, galvanized iron sheets are placed around the culms to contain the smoke. Extra protection is achieved by spraying the smoked culms with insecticides. The bamboos should be bundled and piled horizontally at least 30 cm above the ground in order to protect them from pests. The culms should be sprayed using an insecticidal agent. The pile of culms should then be covered with plastic to protect the culms from the rain.



Treated culms are elevated from the ground and covered.

V. TOOLS FOR BAMBOO WEAVING

The main tools used in plain bamboo weaving are: big knife, scraping knife, blade, saw, pressing rod, and workbench and chair. These tools are displayed in Figure 1 and Figure 2 below.

- Saws are needed for cutting culms into sections. A hacksaw or handsaw may be used. A handsaw can be self-assembled using a saw blade and wooden handle.
- A scraping knife is used for removing the green coat of bamboo culms and to split bamboo sections into slivers. The scraping knife has to be very sharp and durable so that the bamboo culms can be smooth and uniform after scraping. A blade may be used as a substitute of the scraping knife.
- A big knife is needed to divide the bamboo culm sections into slivers. The knife needs to be of a good quality, i.e., made of strong, high grade steel.
- A sharp stripping knife is needed to divide the slivers into fine strips.
- A good pair of scissors is needed to perform the finishing touches of the plain woven design and to cut off protruding strips and threads.
- A pressing rod is a long strip of thin metal. It is mainly used to hold the bamboo woven from moving during the weaving. Normally the size of pressing rod is 5 cm wide, 1-2 cm thick and 20-80 cm long. The pressing rod has to be absolutely straight and flat.
- The workbench and chair should be designed to prevent fatigue for bamboo weavers who need to sit and perform intricate work for many hours. Generally, the workbench is 150 cm long, 20 cm wide, 4-5 cm thick and 70 cm high. The height of the chair should be 35-40 cm. The height of workbench and chair should be adjusted according to the height of the worker so that he/she can work in a comfortable position.

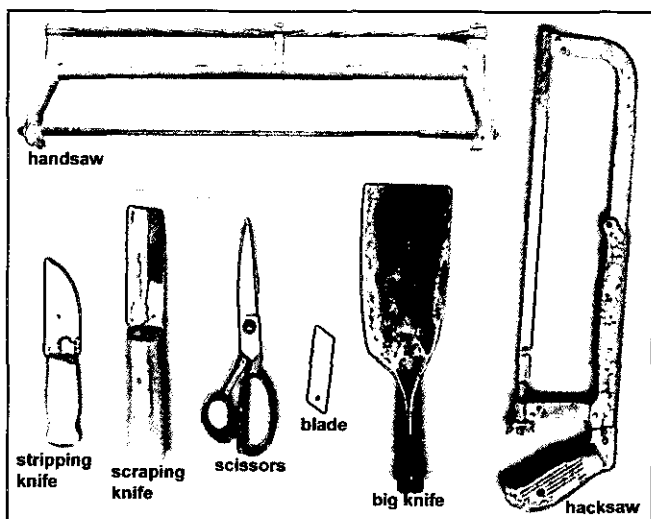


Figure 1



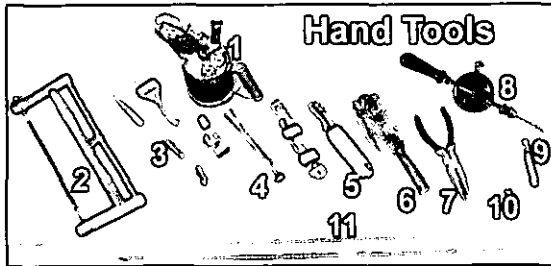
Figure 2

VI. TOOLS FOR BAMBOO FURNITURE MAKING

Bamboo furniture making requires many special tools. The use of electric power tools increases the quality and the efficiency of production in a great way. Power tools also lower the cost of production and contribute to making the bamboo furniture industry more profitable. Using an electric drill instead of a hand powered drill increases the efficiency of the drilling process by over 10 times. Electric saws, planers, and sanding machines are necessary to have a high scale production and their use decreases the total production time and cost of labor. Notwithstanding, many hand tools are still absolutely necessary for manufacturing bamboo furniture. Many of the processes are not mechanized and manual tools are needed for handcrafting in some stages of the production process. The tools needed for manufacturing bamboo furniture are shown and listed below.

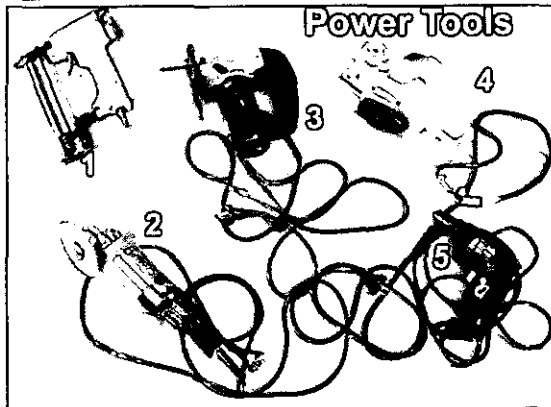
HAND TOOLS

1. Torch
2. Hand saw
3. Shaping knife
4. Chisel
5. Scraping knife
6. Chopping knife
7. Pliers
8. Hand drill
9. Carving tool
10. Drill bits
11. long drill bit



POWER TOOLS

1. Nail gun
2. Rotary saw
3. Jigsaw
4. Planer
5. Drill



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