



Bamboo studies in P.R. China - Summer 2005

A. Badrkhan

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FOREWORD

Bamboo is a known plant almost everywhere in the world, but at the same time not very known. Most consider it to be a tropical plant, but in fact some bamboo species can grow in colder climate.

Bamboo is the most beautiful material one can use. It has the soft and the round shape that eases the eyes and the colors makes one feel close to nature.

My first contact with the plant was when I was staying in a permaculture center in Africa. There I had an assignment to design shelves and other furniture by using bamboo. It was very interesting and challenging task and opened up my eyes for bamboo. However, it was just last year I really decided that it is this plant I wanted to learn more about.

I got in contact with RISF-CAF through an organization that I am a member in, called the Bamboo College Norway. June 2005 I went as the first student for a two months trip to China to study about bamboo. There I met Prof. Gu Xiaoping and his staff guiding me into the world of bamboo. I would like to thank RISF-CAF and Prof. Gu Xiaoping for being the teacher in my bamboo study. It has been a very rich and great experience, I have learned a lot, and I hope to continue my studies under Prof.Gu's supervision.

As for my supervisor at UMB in Norway, Maigull Applegren, I like to thank you for the time, work and encouragement from the starting.

And finally, I would like to thank my family The Bamboo college crew in Norway, thank you.

TRIP TO CHINA

As my trip in China started I was very anxious to learn about bamboo and to get to know Chinese people and Chinese culture. I had never been in this part of the world before and this was quite exciting. My first interest started when I was visiting a permaculture center in Africa; there I had an assignment to design shelves and other furniture by using bamboo.

It was challenging, but really fun. After that my eyes opened up for bamboo. But it was just last year I really decided that bamboo was the plant I wanted to work with in the future.

With the help of prof. Gu as my supervisor in China I had a quite an experience and knowledge that I will take with me in future study in bamboo and therefore I like to thank prof. Gu Xiaoping and his staff for his time and his knowledge through my trip in China. Thank you



Figure 1. Prof. Gu and his staff and the bamboo college staff (photo: Shau Gu 2005).

**INSTITUTE:
THE RESEARCH INSTITUTE OF SUBTROPICAL
FORESTRY OF CHINESE ACADEMY OF FORESTRY
(RISF-CAF).**

RISF-CAF is Research Institute of Subtropical Forestry of Chinese Forestry Academy. Professor Gu Xiaoping is a research professor in this institute. His main research area is bamboo cultivation and ecology. Prof. Gu is a committee Member of Chinese Bamboo Society under Chinese Society of Forestry. He is an adviser of Several Forestry Bureau and Bamboo Process Enterprises in China Work Institutions.

As a researcher at bamboo section of the Research Institute of Subtropical Forestry, CAF since 1982 he has been caring out many projects mainly on bamboo cultivating and utilization, and bamboo forest ecology supported by Ministry of Science and Technology of P. R. China, State Forestry Administration of P. R. China and the government of Zhejiang province of P. R. China.

Prof. Gu Xiaoping was also adviser and a part of building the biggest Bamboo Botanical Garden in Anji, China.

RISF-CAF receives every year new master students from all over China to study at the institute. During my stay, the professor was supervisor for three master students doing their term papers on bamboo.

I got in contact with RISF-CAF through the organization Bamboo College where I am a member.

Bamboo College aims to carry out bamboo culture and other sustainable solutions in Europe, China, and Africa.

In June 2005 I was the first student of plant science and as a member of Bamboo College Norway to study bamboo in China for two months.

During my stay together with prof. Gu Xiaoping and his students we traveled to other provinces in China to see different bamboo and their different stage of growth. It is interesting to see that bamboo play a great role in Chinese culture and history.

THE STUDY PROGRAM IN CHINA

The content of my study basically was to learn the general knowledge about the bamboo plant, from learning bamboo taxonomy, and bamboo biological and ecological characteristics, to obtain the practical techniques in bamboo forest cultivation and in the harvest of bamboo products.

Starting by asking why bamboo, why does this plant capture our interest, what is so great about it that makes it so important to spend time, energy and research to get to know it better. In the European countries bamboo is not very known or used. Usually bamboo is seen as a tropical plant, but in fact it can grow well in cold climates too.

The research of bamboo plant is quite advanced in Asia, and in China bamboo is considered as a holy plant, because it is of great economical importance, for example in the paper industry.

Bamboo

In order to start learning about the bamboo plant, I had to become familiar with the plant, starting by the root system, the rhizomes.

Bamboo has three different root systems: Sympodial (clumping rhizome type), Monopodial (running rhizome type) and Amphipodial (mixture of running and clumping rhizome type). The running bamboo rhizome grows also in colder climates, while the clumping rhizome grows mainly in warmer climates. I chose to focus on clumping rhizome type, as my main focus will be on bamboo growing in warm climates.

Bamboo is a plant that has many uses. It is important to know what the plant will be used for when selecting the genotype. The climatic conditions, water supply and soil are important factors for good growth and development of bamboo.

The soil should not be watertight or compact, because the roots and rhizomes need air. If the soil is too tight, the rhizome will seek air by coming out of the soil, and get exposed to light. This can damage the rhizome and the bamboo plants will not look healthy.

Bamboo can be cultivated by using rhizome, culms, branches or seeds. The two last methods take longer time to grow large culms diameter than the two first methods. More details are explained in the report.

The content of the study

1. Taxonomy of bamboo

Bamboo is a giant grass/tree from Gramineae (Poaceae) family.

It grows from a network of rhizomes; some people call them underground stems.

Culms and roots grow from the rhizomes.

In the spring new culms grow from this network of rhizomes. The shoots, which are young culms coming out from the ground full sized in diameter can reach a maximum height within a couple of months.

It is easy to see why bamboo is often said to be the fastest growing plant. Some shoots can grow as much as half a meter or more in 24 hours. (Gu pers. comm.)

My trip in China started by visiting the Bamboo Botanical Garden in Anji, which was founded by the help and knowledge of prof. Gu Xiaoping.

Since I had no knowledge about Bamboo, it was a great place to start from.

Species of Bamboo can sometimes look very similar, but as I wandered along the Bamboo garden, I realized that small details could reveal the appearance of each species.

I will not go in details about species name, as it is extremely difficult for me to remember the Latin names. But I like to mention some details that helped me, to understand the differences between the species.

My observations in the garden

Bamboo culms can have different appearances:

- Green collar with one yellow stripe
- Green w/ one faded yellow stripe
- Green w/ many yellow stripes
- Green w/ black spots
- Yellow w/ one green stripe
- Yellow w/ many green stripes
- Squared culms
- Different length in the internodes
- Braded shape
- Different small bushy bamboo

And much more.

In the Bamboo Botanical Garden there were many different species with different rhizome systems. I was introduced to all the rhizome systems. It was difficult for me to tell the difference between the rhizomes, because some of them looked very similar.

I also had the chance to see many different species of bamboo in different stages, some had large and some small culm diameter, and some species were bushes and some big forest trees.



Figure 2. Bamboo culms in Anji Botanical bamboo Garden (Photo: Badrkhan 2005).

2. The biological and ecological characteristics of all kinds of bamboo Species

The trip to the Bamboo Garden in Anji was basically to learn about characteristics of bamboo. The characteristics of Monopodial bamboo (running bamboo) are that the culms can grow in different places. Like their name, running bamboo, they can run a long distance and take over the forest in a matter of a short time. In the report it is recommended to plant running bamboo in controlled area, to avoid them taking over the field. In the Bamboo Botanical Garden running bamboos were controlled by placing Cement wall for them to stop running. Monopodial bamboos can also be controlled by digging trench around them to control them. (Gu pers.comm.)

In some places in Australia bamboo is seen as a problem and even banned. This is because monopodial bamboo has taken over as the main tree in the forest. This is obvious that their knowledge of bamboo is poor (Cusack 1997).

Bamboos can survive for a short time in water, but they are not aquatic genera so the roots cannot take an anaerobic environment for a long time.

3. The bamboo forestation techniques and nursery techniques of sympodial bamboos

A forest can be produced in a matter of few years. The fastest way is to plant rhizome or culms, while planting branches or seeds take few more years before their diameter and length becomes larger.

Visiting Winzhou Province in China professor Gu took me to some places to see the differences in the growth of planted bamboo fields. As seen in figure 3 and 4, the bamboo shoots look big around their diameter, because the rhizomes are used for propagation. When shoots look small in diameter, it reveals that branches or seeds are used for propagation.

For further information, section propagation.

4. The management and cultivation techniques of bamboo.

It is not difficult to cultivate bamboo; one must know what kind of use one wish from the bamboo before deciding what kind of bamboo specie that can be cultivated.

When shoots are harvested usually the clump look much better and the shoots are also harvested because it stimulates rhizome buds to grow new shoots.

To stimulate the growth of bamboo, it is important to:

- Add nutrition (mainly Nitrogen) to the young plants or to new shoots
- Harvesting shoots/culms regularly
- The soil should not be tight or water tight
- Make sure that there is no insect attack



Figure 3. Harvesting bamboo shoots (Photo. Badrkhan 2005)



Figure 4. Bamboo shoots ready to be harvested (Photo: Badrkhan 2005).

5. To investigate the process and utilization of bamboo.

The use of bamboo is very important. If the bamboo is not used, there is no point in planting them. That is why the utilization of bamboo has just as importance as planting the bamboo. Bamboo can be used for many things. I visited some factories in China to see the development of the use of bamboo. Bamboo is a plant that has been used a lot in China and has a great place in Chinese history. The utilization of bamboo is very advanced in China and in Asia.

The Utilization of bamboo:

Bamboo used for food:

It is usually the soft parts of bamboo that could be eaten, like the shoots.

The shoot can be prepared in many ways. We visited factories, and visited restaurant where bamboo shoots were prepared before eating. Bamboo shoots can be prepared in many ways. They can be eaten fresh, dried, frozen, hermetic bamboo shoots, and other methods are tried out. To export such a product, factories have been doing different research on how to preserve the bamboo in best way, by drying, freezing and hermetic to keep them for a long time without becoming destroyed. However, it is very difficult to keep the taste of the newly harvested bamboo shoot.

When bamboo shoots are harvested, they should be prepared right away, before the crispiness and the fresh taste will vanish. This is the problem with bamboo for food. The shoots become quickly old and difficult to chew after less than 24 hours. That is why fresh shoots are not exported.

I have tasted a lot of different bamboo shoots. In Zejiang province where I was staying, Sympodial bamboo could not grow well, so we went to other provinces to see Sympodial bamboo and that is why in every province we could taste a new bamboo.

I have tasted monopodial bamboo shoots in Zejiang province where I stayed because it is there monopodial bamboo grew best. In Whinzou Province I tasted Sympodial bamboo shoots, because it is a good growth of Sympodial bamboo.

It is now easy for me even to tell how long since the shoot were harvested and distinguish the preservation method before cooking.

Bamboo used for furniture:

When bamboo is used for furniture, it is important to choose species that are solid so that if they are bended they do not brake. That means the culms should have thick walls, many monopodium bamboo culms have thin culms wall. Both thin and thick bamboo culms can be bended. Some species of bamboo dos not have hollow culms; they are very solid for bending (Adams 2005). Bamboo can be bended by steam. Bamboo is bended basically for making beautiful furniture. Bamboo culms are used for weaving. Usually the bamboo culms are cut and made into strips for weaving. These strips have to be placed in water before they are used for weaving baskets or other things. We visited a weaving factory In Fuyang Province where workers where cutting strips and making the strips ready for weaving. Just the cutting was an art not many could have done.

Bamboo used for papermaking:

Paper is made from bamboo fibers from the culms. I visited a very large paper factory in Fuyang Province and their bamboo field. There are still some small papers factories left in China which make paper in the old way. The bamboo paper making technology is very advanced in China, and this is due to the long history of Chinese papermaking.



Figure 5. Paper factory in China (Photo: Badrkhan 2005)

To answer some of the questions above, bamboo can have great importance for the future. As we cut down all our trees and our industries are depended on these trees, it may eradicate most of the species. It is not possible to balance the economics that are depended on these resources that are taken. Bamboo can be a solution.

Bamboo is a fast growing plant and can grow up to a meter in a day. The growth is also stimulated when harvested regularly. It is a unique plant and has versatile use as for example: papermaking, house building, carbon, food and many other things. It is not necessary to cut so many trees, which may take years and years to replace, when one can use bamboo that takes only one year to reach full vegetative height. To accomplish a sustainable development of forestry and economical benefits, bamboo should replace wood and bamboo dos not only grow in warm climates but also in the cold.

Deeper understanding of the bamboo plant is to found in General Description of Bamboo in the second paper.

SYMPODIAL BAMBOO



INTRODUCTION

This report is a general description of bamboo with the main focus on Symopodial rhizome type. Species are barely mentioned, as it needs more research and many years of study. Some of the information is taken from the Internet and some from books, but mostly notes from Prof. Gu's lectures.

The report starts with an introduction to the bamboo plant and taxonomy. It continues with a detailed description of the plant, followed by cultivating methods and management, propagation of bamboo, nutrition and fertilizing bamboo, and a brief knowledge of insect attack.

Utilization of bamboo, which has an important role of why one, should cultivate bamboo. Finally with a conclusion of why using bamboo and what kind of importance it has on a global economy.

GENERAL INTRODUCTION TO BAMBOO

Bamboo represents one of the world's greatest natural and renewable resources.



Figure 1-1. Bamboo Botanical Garden in Anji (Photo: Badrkhan 2005).

Bamboo looks like a giant grass or a tree with a fast growing ability. Some species can grow up to 30 meter in height and 30 centimeter in diameter, all depending on the genera, water, nutrition and the temperature.

Over 75 genera and 1250 species are reported to occur in the globe. Only 39 genera and 500 species are found in China.

Bamboo can grow in three main areas.

- South- East Asia (Thailand, Indonesia, Malaysia, China, India, Japan, aso.)
- South America and some parts of Central America
- Africa

The trees usually like to grow in humid, warm climate, but some species can also grow in cold climate. They do not like much the windy climate, as it will cause loss of water.

Bamboo plants are often used to prevent soil from erosion, because of their rhizome system that keeps the soil together.

In China, bamboo has played an important part in the spread and development of traditional Chinese culture. Bamboo was closely connected with the daily lives of people in ancient China. The people of the time used bamboo as firewood, to make tiles, paper, rafts, hats, and shoes. At that time, as today, bamboo shoots were eaten as a popular dish because of their crispness and fresh, sweet taste. Bamboo shoots also contain vitamins, sugar, fat, and protein.

Today, bamboo is widely used for household articles such as mats, beds, pillows, benches, chairs, cabinets, charcoal, buckets, chopsticks, spoons, baskets, and handheld fans. It is also used to make traditional Chinese musical instruments.

Bamboo weaving is popular in the provinces of Guangdong, Fujian, Hunan, Sichuan, and Anhui as well as Zhejiang, which have a history of bamboo weaving going back more than 2 000 years. Bamboo is also used as tee and in Chinese medicine. Bamboo's resistance to stretching and its ability to support weight are at least double those of other kinds of wood, making bamboo an ideal material for houses, scaffolding, supporting pillars, and work sheds. Tall and graceful with luxuriant foliage, bamboo is an ideal plant for household courtyards and parks. It tolerates the heat of summer and the cold of winter, it grows on unfertile land, and it regenerates after being cut.
(Gu personal communication)

General description of bamboo plant:

Bamboos are classified into three types, depending on the production of rhizomes:

- 1- Monopodial bamboo (running rhizome structure): the rhizome having one or two bud at each node that develops every year.
- 2- Sympodial bamboo (clumping rhizome structure): there are two types of sympodial bamboo rhizome. One is called sympodial clumping rhizome and the other sympodial single type (figure 1-2). The apex of the rhizome has nodes, but does not grow like monopodial bamboo. The bud on the basal part of the culm develops into a short rhizome that protrudes out of the ground to make the secondary culm, thus forming a clump.
- 3- Amphipodial/Intermediate (mix. Rhizome structure): Amphipodial bamboo is a mixture between monopodial and sympodial rhizome.

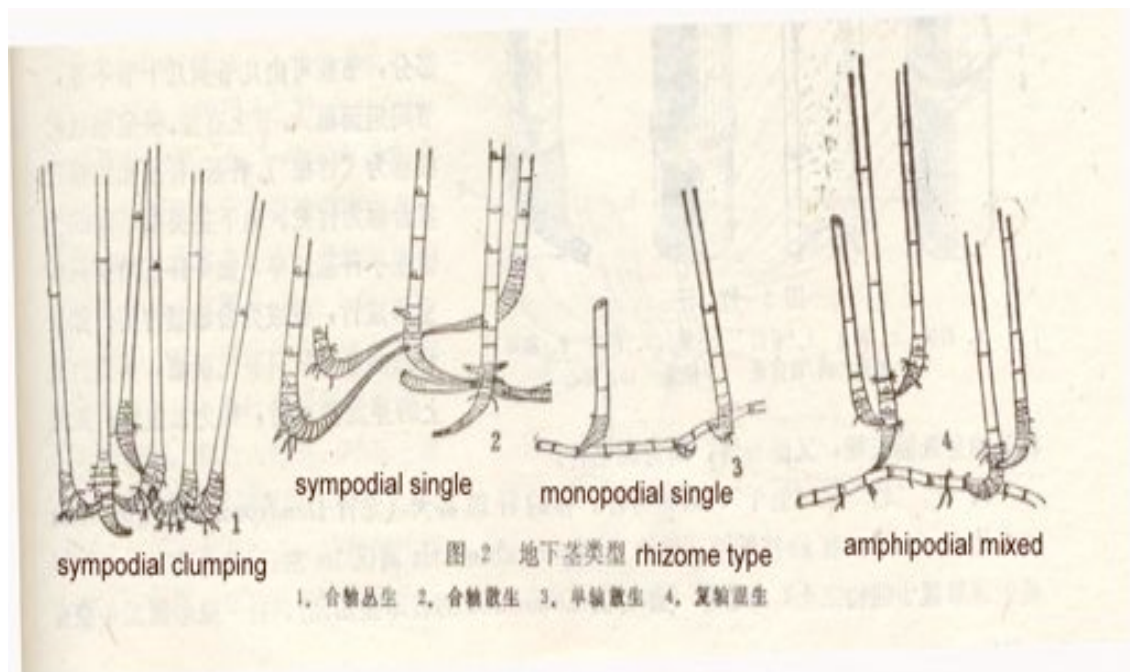


Figure 1-2. Four different rhizome types: Sympodial clumping, Sympodial single, Monopodial single and Amphipodial mixed (Chinese text book written in Chinese).

In China, new species of both clumping and running are discovered regularly. Basically, clumping bamboos are shallow-rooted, rainforest-type plants. While most will grow in total sunlight, most also grow in a dense canopy environment.

Their growth area is limited by the fact that each rhizome develops just a single culm or pole and can travel only the length of the rhizome neck. Most clumping bamboo are more tropical or subtropical than running bamboo, but many are still very cold tolerant. Some originate in the high mountain country of northern China where they survive temperatures of minus 20° (Cusack 1997).

Running (monopodial) bamboos differ from clumping bamboos in such a multitude of ways that they should be seen as totally different plants. They are naturally dominant Forest plants and is not suited to the environment beneath a rainforest canopy. The rhizomes of running bamboo are usually long, outgoing, adventurous, solid or semi-solid underground canes that support a dense, fine, root system. These rhizomes develop buds at almost every internode. A single rhizome can produce many culms and many rhizomes every year, because each bud develops into either another rhizome or a culm. Each rhizome again can produce many culms and rhizomes the following year. All running bamboos will grow in almost all climates, but most seem to grow very vigorously in mild temperate or sub-tropical areas, if growing conditions are reasonable.

Running bamboos can be very beautiful but should be planted in a controlled environment otherwise they spread and get out of control.

Bamboo has two kinds of flowering behaviors, firstly sporadic and irregular flowering behaviors:

- 1- Sporadic and irregular flowering
- 2- Secondly periodical gregarious flowering

The gregarious flowering is followed by the death of the clump and varies from 20 to 75 years depending upon the locality, management practices and biotic interferences.

After the flowering occurs, as mentioned all the existing culms die off, and the bamboo seed is only viable for six months. This can cause great problems for people or businesses dependent on a constant supply of culms.

A complete bamboo plant consists of three morphologic structures, the leafy aerial part (the culm) and two underground parts (the rhizome and the roots). For successful growth all these structures must develop. The new seedlings produce a rhizome (the seedlings resembles a blade of grass), which develop new rhizomes that produce culms. The number of new rhizomes may vary from one to many.

Bamboo was originally classified as a woody member of the grass family, Gramineae, a monocot rather than a dicot, thus having no cambium layer or bark. This classification causes considerable unease among some taxonomists and botanical scientists who feel that bamboo should be classified as a family on its own.

There are features that set them apart from grasses, such as branch systems, petiolated Leaves and the hollow structure divided by diaphragms. Not all bamboos are hollow, in fact some of the strongest, medium-sized, clumping bamboos are either completely solid,

or almost so far about half they're height- *Bambusa tulda*, *Bambusa nana*, *Bambusa polymorpha*, *Gigantochloa albociliata*, *Dendrocalamus strictus*. There are also some small bamboos used for hedges. Often bamboo is mistaken for 'cane' or rattan, which is actually a solid, flexible member of the palm tree family, *Palmae*. Like bamboo, rattan is also used to make furniture, and is often split to bind the joints of bamboo furniture.

Taxonomical identification of bamboo creates problems because the scientists do not agree about the species they find and because the Latin-based botanical naming system relies heavily on the description of the flower and its associated support (panicle) to classify plants into genus and species. Most bamboo rarely flowers, some only every 100 years. Bamboo is not grown in the Middle East or anywhere else in Europe, but it has become a popular garden plant in both regions.

Table 1-1. Classification of bamboo (Gu Xiaoping):

| CATEGORY | TAXON |
|----------|-------------------------------------|
| KINGDOM | <i>Plantae</i> |
| PHYLUM | <i>Spermatophyta</i> |
| CLASS | <i>Monocotyledoneae</i> |
| ORDER | <i>Graminales</i> |
| FAMILY | <i>Gramineae</i> |
| GENUS | More than 70 genus in the world |
| SPECIES | More than 1200 species in the world |

Angiospermae

Monocotyledoneae

Glumiflorae

GRAMINEAE (Belong to the bamboo, rice, corn, wheat): Bambusoideae

Unit:

- Bambusatae
- Arundinariaiue

Sub- unit:

- Shibataeae
- Phyllostachys
- Phyllostachys bamboosoides

Culm, shoots, leaf and sheaths are used to classify bamboo plants.

Monopodial bamboo planted by seeds has some characters of sympodial bamboo. The rhizome can have active buds but when they grow older, they cannot grow buds on the "rhizome" while sympodial bamboo rhizome can grow buds.

Table 1-2. The number of branches according to the species (Gu Xiaoping):

| Number of branches | Species of bamboo |
|-------------------------------|--|
| 1 | <i>Sasa</i> , <i>Indocalamus</i> , <i>Ferocalamus</i> |
| 2 | <i>Phyllostachys</i> |
| 3 | <i>Chimonobambusa</i> , <i>Indosasa</i> , <i>Sinobambusa</i> , <i>Semiarundinaria</i> , <i>Oligostachyum</i> , <i>Acidosasa</i> |
| Many small and one big branch | <i>Bambusa</i> , <i>Dendrocalamus</i> |
| 1, 2 or 3 | <i>Pseudosasa</i> |
| 3 - 7 | <i>Pleioblastus</i> , <i>Shibataea</i> |
| 7 - 12 | <i>Gleidocalamus</i> |
| More than 12 | <i>Melocana</i> , <i>Leptocanna</i> , <i>Schizostachyum</i> , <i>Pseudostachyum</i> , <i>Thyrsostachys</i> |

It is difficult to find a good book about bamboo classification, as many scientists cannot agree about the criteria for classification.

PLANT DESCRIPTION

Flowering cycle and genera

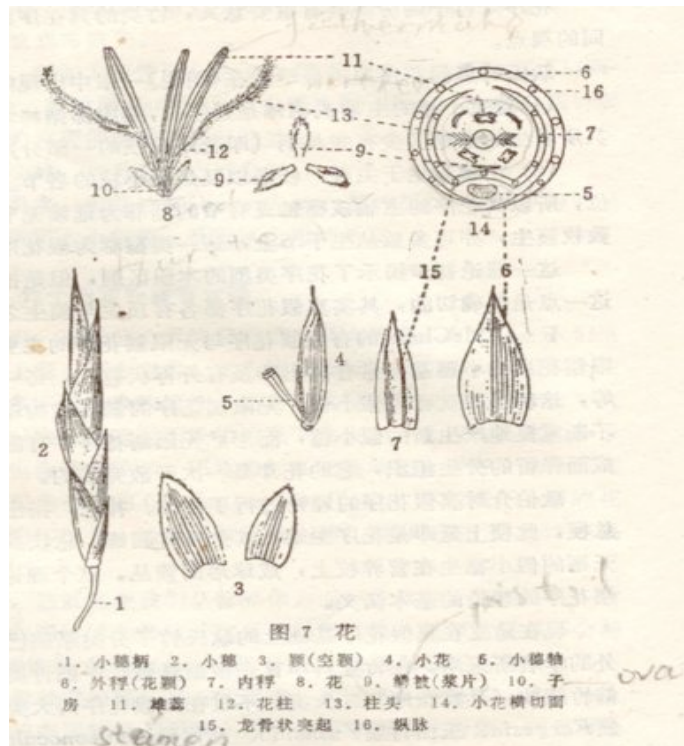


Figure 2-1. Flower and floral diagram of bamboo (From the Chinese textbook written in Chinese).

The following descriptions of the parts of clumping plants should be read by paying attention to figure 2-2. This figure shows the rhizome system of sympodial bamboo. Each 'pole' generated by a bamboo clump is called a culm. It is a hollow, 'Woody', round section divided into compartments by diaphragms called nodes. The length between nodes, internode, is different depending on the species and the diameter of the culm.

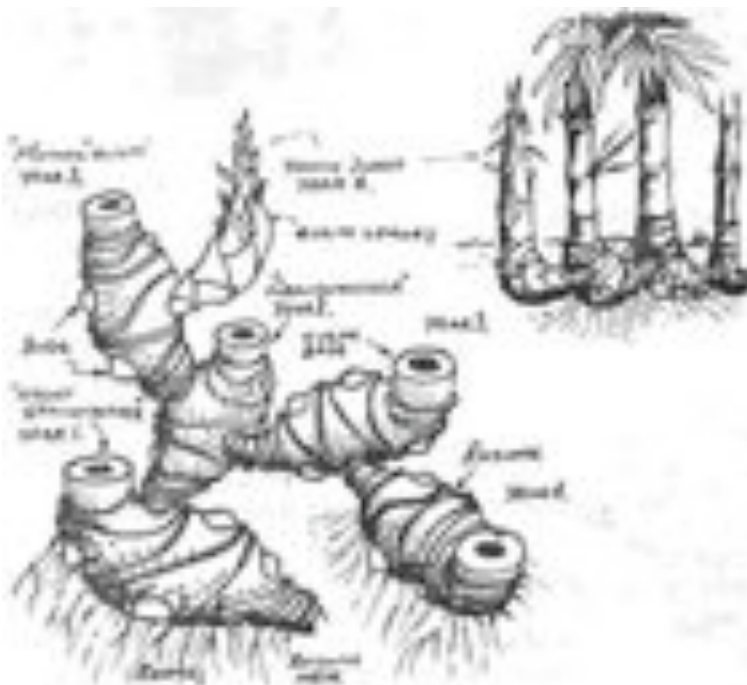


Figure 2-2. Rhizome structure of clumping bamboos. Each rhizome develops just a single culm (Cusack 1997).

The internodes of most large, structural bamboos vary between 300 and 600 mm, but some smaller species with culms only 30 mm diameter or smaller develop internodes up to one meter long.

The thickness of a culm's wall varies with the genera and species. Some heavy-walled species are very good for structural use. While thin-walled bamboo species are good for splitting for use in fences, screens and baskets. Certain bamboos have such thick walls that the hole in the middle disappears and the culm is solid for all or part of its length. This type of bamboo is good for bending when green, by heat or steam, because being solid prevents the bamboo from collapsing during the bending process. (Cusack 1997)

Rhizome systems

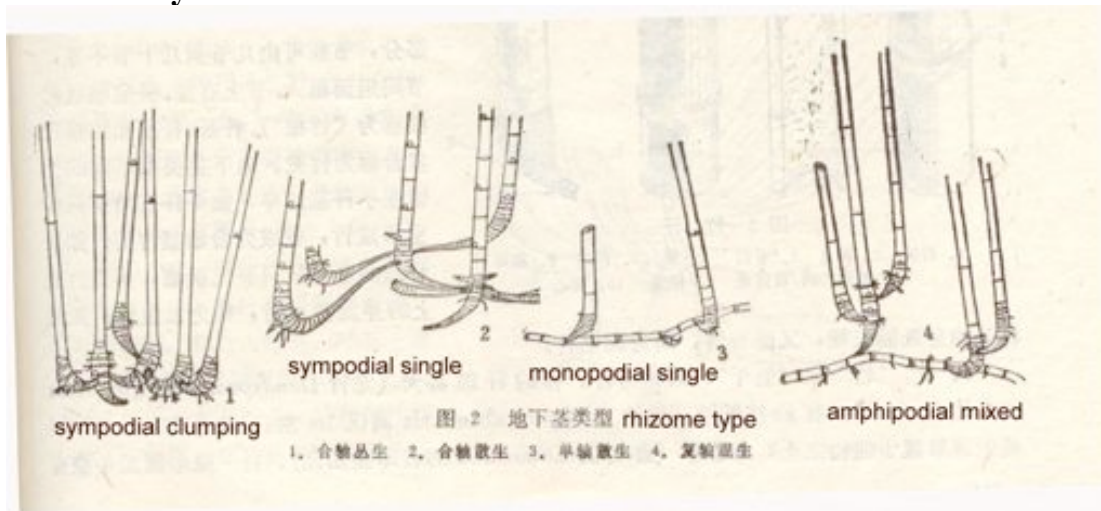


Figure 2-3. Four different rhizome types: Sympodial clumping, Sympodial single, Monopodial single and Amphipodial mixed (Chinese text book written in Chinese).

A mature clumping rhizome generally has only one or two new rhizomes and shoots per year, but can have three or more. This accounts for the multiplication of culms in a young clump (sympodial bamboo creates clumping system where many bamboos grow very tight next to one another).

The rhizome is the woody section joined by a neck to the mother rhizome, where the bud has developed. Each rhizome carries a number of dormant buds that can be activated in later seasons. The culm, growing as a result of developed shoot grows out from the end of the rhizome. And from there emerges from the ground and achieve a maximum diameter.

Both the maximum wall thickness and the maximum diameter are achieved during the first two or three months as the developing culm catapults into the air. The thickness of the culm wall always reduces with height. But some species produce culms that are smaller in diameter and with shorter internodes near the base, and then increase in diameter and lengthen their internodes as they climb higher.

Each new culm on a clumping bamboo develops from a single shoot that develops vertically from a single rhizome. These culms have developed from a bud on the mother rhizome and culm. The new rhizome with its shoot depends on the mother culm, grandmother culm, and so on, as well as the clump's mature rhizome system to supply all its needs like starch (and other needs) as it grows towards full height. New culms can reach 90% of their full height from a shoot within two to three months, sometimes reaching a growth rate of up to a meter a day during the maximum growth period (at about the mid-height stage) (Cusack 1997).

After reaching approximately 90% of full height, the growth slows down and the last 10% of the growth takes much longer time, sometimes up to a year. Most young culms are covered in a white powder made up mostly of wax and silicon. This white color usually fades with age, but it remains on some species.

Bamboo culms



Figure 2-4. The bamboo culm is used also too classify bamboo (Armstrong 2003).

When the shoot emerges from the ground, there are many integrated nodes. The internodes develop rapidly, this way they separate each of the nodes and telescope the developing culm rapidly into the air. The telescoping takes place from the bottom of the culm upwards. As the telescoping takes the shoot up-wards into the air, the growth of the top is slower than the growth of the bottom and middle.

The culms have no vegetative leaves until after they reach full height. Branch structures and leaves develop from the top to down, usually quite slowly. Most species take up to 12 months or longer to develop their full growth of branches and leaves. The newly developed culm then joins the other mature culms within the clump, building up starch and sap to feed the new buds on the rhizomes and culms due to appear during the summer (Cusack 1997).

Young shoots that eventually grow into culm consist mostly from water and have no fiber or strength to resist snapping. During this period, usually shoots and culms are wrapped in by culm leaves, which are very important for them until the culm develops fiber to become self supporting (Cusack 1997).

Culms leaves of some species are covered in aggressive hairs that can cause irritation to the skin or digestive system (personal experiences). The fiber in the culms develops from bottom upwards, and the culm leaves progressively die, also from the bottom up, and mostly drop off once they have served their purpose (Cusack 1997).

Culm leaves are different in shape and size according to their location along the culm, but also different according to species. For this reason, many taxonomists use the culm leaf (the sheath) as one of the major identification tools for different species.



Figure 2-5. Wild sympodial bamboo in Winzou Province, China (Photo: Badrkhan 2005).

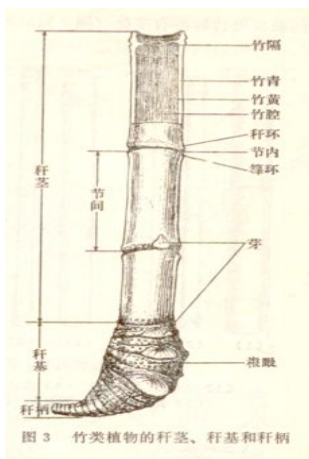


Figure 2-6. A sympodial bamboo culm (clumping bamboo) with nodes, buds and internodes. (From the Chinese text book written in Chinese)

Harvesting culms and shoots regularly make the clumps easier to manage and they will also look nicer. The growth of a clumping bamboo has a defined pattern. All the rhizomes are located within the boundary of the outer culm that grows out of the soil at shoot season, each culm from its own rhizome. Every rhizome sends out long and fine roots in large circle to feed the clump, often up to three or four times the diameter of the clump itself. These roots are not capable of propagating new plants, but they bind the soil. This is why clumping bamboos are so effective against soil or riverbank erosion.

Length and the growth of the culm

In a shoot it is possible to see the number of nodes that the bamboo will develop, but not the length of the internodes, because there are many factors that can affect this process. The top and the bottom of the shoot has shorter internodes, climate has a big impact on this. If the temperature is high, the internodes will stretch more.

Table 2-1. An example of how tall the bamboo tree can grow in a matter of two months or less (Gu pers. comm.).

| Days | Nodes growing from bottom, node no.1-24 | Number of nodes growing in a day | The speed of growth |
|--------------|---|----------------------------------|---------------------|
| First day | Node no. 1-3 | 3 nodes in a day | Slow growth |
| Second day | Node no. 2-4 | 3 | |
| Third day | Node no. 4-6 | 3 | |
| Fourth day | Node no. 5-8 | 4 | |
| Fifth day | Node no. 7-11 | 5 | |
| Sixth day | Node no. 9-14 | 6 | Fast growth |
| Seventh day | Node no. 10-17 | 8 | |
| “ | “ | “ | |
| “ | “ | “ | |
| Tenth day | Node no. 15-20 | 6 | |
| Eleventh day | Node no. 17-22 | 6 | |
| Twelve day | Node no. 19-24 | 3 | Slow growth |
| Aso | Aso | Aso | |

Table 2-1 shows the ground nodes (node 1-6) and nodes in the top section of the bamboo tree (node 19->) grow slower than the nodes in the middle. The middle nodes, (node 9-17), grow fast. After the bamboo stop growing, the length get fixed, then the branches and the leaves start to grow out.

As earlier explained, climate can affect the growth of bamboo.

If the temperature is 10°C, the bamboo can grow at least 5 cm in that day, but if the temperature changes to 4°C the next day, that temperature change can affect the growth immediately and the shoot will only grow 2 cm that day.

Parenchyma tissue

the basic/ground tissue of the culm (parenchyma cells), which is mostly vertically elongated with short, cube/like ones interspersed in between. The parenchyma cells are characterized by thicker walls with poly-lamellate structure. They become lignified already in the early stages of shoot growth but can still be alive in culms older than 10 years. The shorter cells have a denser cytoplasm and thinner walls. The function of these two different types of parenchyma is still unknown. The outer wall parenchyma of the culm is harder than the inner wall. The vascular bundle in the outer wall is tighter and

closed type, while the vascular bundle in the inner wall is more open type (Shanmughavel and Francis 2001).

Fibers

The fibers contribute 60-70 % of the weight of total culm tissue. They are long and tapered at their ends. The ratio of length to width varies between 150:1 and 250:1. The length shows considerable variation between and within species. Generally the fibers are much longer than those from hardwoods (1-1.5mm). Different values have been reported for one and the same species. The reason is mainly due to considerable variation of fiber length within one culm. Across the culm wall the fiber length increase from the periphery towards the middle and decrease towards the inner part (Shanmughavel and Francis 2001).

Vascular bundle in culm

Different species of bamboo has different wall thickness, with a couple species being entirely solid. Bamboo is a natural composite. The walls are composed of "vascular bundles" of which there are five types.



Figure 2-7. Vascular bundle types of bamboo. 1- Double break waist and 2- Break waist (vascular bundles in sympodial bamboo), 3- Tight waist (amphipodial mixed bamboo vascular bundle), 4- Open type and 5- Sim open type (Monopodial bamboo vascular bundles) (The Chinese text book in Chinese).

The vascular bundles evolution is ordered from 1 to 5 (Figure 2-7). Nr 5 is the newest type from evolution. It is not always easy to tell which vascular bundle belongs to sympodial bamboo, because they sometimes have vascular bundle type nr. 1, 2, and 3. The classification is determined by the most vascular bundle that will be found in the culm. There are different vascular bundles in the inner wall and outer wall of the culm. The outer wall does not have vessel, only fiber, that is why it looks more compact. The water cannot be transported in this part of the culm, this causes a dry outer wall and that is why the outer wall becomes hard (Shanmughavel and Francis 2001).

Layer of vascular bundle in the culm:

- 1- The outer wall layer of vascular bundles does not have vessel, consist almost only of fiber.
- 2- The middle wall layer has very clear appearance of vascular bundle types and we easily can determine what kind of vascular bundle we have.
- 3- The inner wall layer has mixed vascular bundle types (Shanmughavel and Francis 2001).

Bamboo shoot growth

The shoot looks like a mini culm that has nodes. The internodes consist of an intercalary meristem. The upper part of the shoot differentiates into various cell types, which elongate, while the lower part keeps its meristematic activity.

The shoot diameter shows thickness of the culm, because it is already fixed. The length of the shoot is not predicted, as the internodes will stretch.

The bamboo nodes have a thin layer inside which separate them from other plants. These thin layers separate the internodes in each node and they are easy breakable.

When the shoots are exposed to the sunlight, they become green and bitter

(Figure 2-8). These shoots are not harvested.



Figure 2-8. Bamboo shoots exposed to the light (Photo: Badrkhan 2005).

Sheath

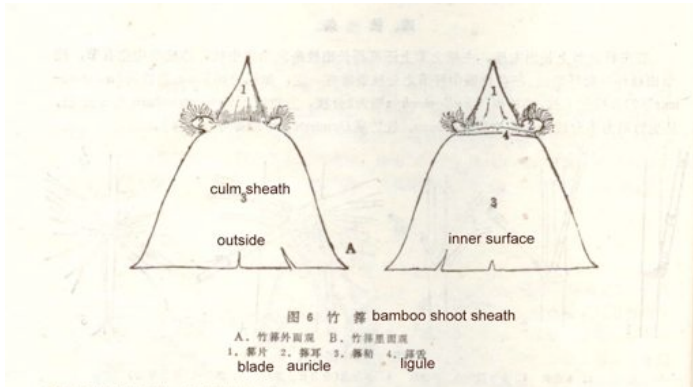


Figure 2-9. Bamboo sheath (Chinese textbook).

Taxonomists usually use the sheath (Figure 2-9) to identify different bamboo species. For most bamboo the culm sheaths are different in the culm top, middle and ground. The most mentioned sheaths are the sheaths in the middle part of the culm, as it is the ones we usually can reach. Some bamboo species have sheaths with incredible aggressive short hair and this causes irritation to the skin (Figure 2-10a and b). Every sheath has two auricles (ears) on each side of the blade.



Figure 2-10a. Culm sheaths (Photo: Badrkhan 2005).



Figure 2-10b. Young shoot with sheaths (Photo: Badrkhan 2005).

Leaves

The bamboo leaves (Figure 2-11a and b) are not taken very seriously, but they are used to classify some bamboo species.

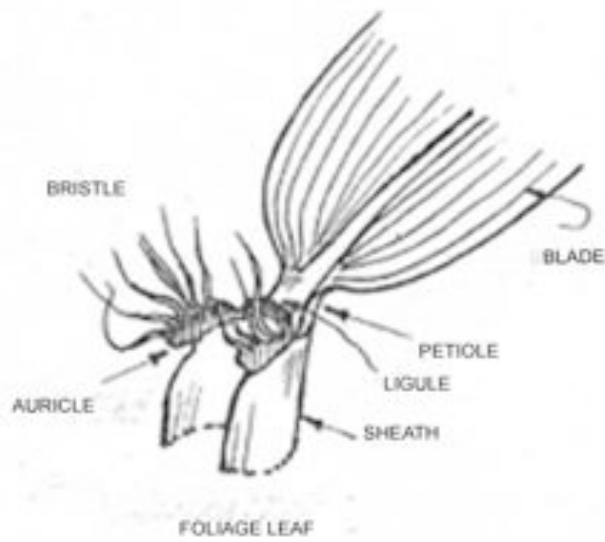


Figure 2-11a. Bamboo foliage leaf with details (Chinese text book).



Figure 11b. Bamboo leaf with bristles (Photo: Badrkhan 2005).

Flower, fruit and seed

The scientists can predict when bamboo bloom. They can predict it by studying the bamboo leaf size. The flower, fruits and seeds are studied to determine different trees. This is difficult to do in bamboo, because it hardly blooms. Therefore the sheath or the culms are used to classify the bamboo. The coat of the fruit and the seed are attached together, they are inseparable (caryopsis) looks like wheat and apple (Gu pers. comm.).

CULTIVATING AND MANAGEMENT OF BAMBOO

A brief cultivation and management of bamboos

1- Seedling from tissue culture should be used. 20 * 30 sized polythene bags are filled with soil, sand and manure (Figure 3-1). About 5 to 20 plants are planted in each polythene bag. Watering should be done 2 to 3 times a day and care is to be taken to avoid over saturation. Seedlings can be kept in these bags for one month.



Figure 3-1. Seedling from tissue culture (Photo: Badrkhan 2005).

2- The nursery should always be raised in shades.

- 3- The bags containing the seedlings should have number of rhizomes from 4 to 5. These set of rhizomes are not separated out or sorted, but the entire thing in the bags should be planted in the field.
- 4- The seedlings in the nursery should be transplanted to 45* 45* 45cm pits in the fields at a spacing of 6 * 6 m (one week before planting the pits should be treated with 0.01 % aldrex and 0.05% bavistin to prevent termite and fungal attack.
- 5- Watering is the essential, but over watering should be avoided.
- 6- The transplanted seedlings may produce rhizome, which would develop new rhizomes that produces culms. The number of culms developed from the rhizome totally becomes the basic of a clump.
- 7- The production of new culms may depend on the culms from the previous year and the clump age. The culms produced during the first year may be shorter in length and smaller in diameter, while culms from subsequent years will be longer in length and bigger in diameter.
- 8- The rhizome may develop in any direction and the culms may appear anywhere in the clump. The new culms can even be seen in the middle of the clump.
- 9- New culms are produced every year. Older culms should therefore be harvested each year. Culms older than two years took little part in the growth of new culms. Culms older than two years are therefore not needed for the production of new culms. Culms older than three years are mature enough for any wishful use.
 - All bamboo culms three years older should be harvested.
 - Each year should the bamboo be harvested, it is good for the bamboo clump.
 - If there are many culms, they should be removed even if it produces leaves in the current year culms.
 - Where the young culms are twisted from the top, they should be cut so the new culms can grow freely.
 - The cutting of culms should not be carried out from July to October.
 - Earth should be gathered around the bamboo clumps after every felling of culms.

(Shanmughavel & Francis 2001)

A good way to avoid weed is to plant vegetables together with the seedlings. They grow well together the first 1-2 years, after this time the bamboos grow tall and become the dominant plant and make shadow for the other plants, these vegetables will not get enough sunlight and may not survive much longer.

This method has two advantages:

- 1-The vegetables are planted with the young bamboos to avoid weed.

2-When nutrition is given to the vegetables, also the young bamboos benefit from the nutrition.

Almost all vegetables can be planted with the seedlings, but the vegetables should not be taller than the seedlings.

How to transplant bamboo

There are three methods of cultivating bamboo.

We can plant the culm, rhizome and seeds. The culm and rhizomes are mostly planted, because it is difficult to get bamboo seeds.

The trees are transplanted during the spring when they are dormant.

Method-1:

Before transplanting bamboo, we need to pay attention to few things that are extremely important.

1- Select good species

2- A young bamboo should be selected, because the rhizome is still young and can produce new bamboos. If we chose an old bamboo, the rhizome has not any buds left to produce new bamboos. In order to tell the age of the bamboo, one should look for different signs on the bamboo culm. One of the most common sign is that bamboo culm is covered by wax. When the age of the culm is known, the age of the rhizome is also known. The rhizome is older than the bamboo, from 0.5 to 3 years.

3- The size of the bamboo culm should be middle sized, neither big nor small. A big bamboo could be difficult to transplant and a small bamboo can easily get damaged by the wind.

4- The branches are trimmed and the culms are transplanted with at least 60 cm rhizome. The top is removed right after the bamboo is placed in the pit. 3-5 branches should be left on the culm.

5- The bamboos for transplanting should not be taken from the middle of the bamboo garden, but from the sides, these are most suitable for propagation. These bamboos have more branches on the lower section of the culm.

6- The rhizome neck can easily be damaged and needs careful handling. Without the rhizome, it is not possible to plant monopodial bamboo. Monopodial bamboo has buds on the rhizome neck just like sympodial bamboo, but the buds will not grow out. In one hectare 800-1200 bamboo trees can be planted.

Method- 2:

The rhizome is used for transplanting.

- 1- A young yellow rhizome is selected.
- 2- The rhizome should be covered with soil when transplanted. In warmer countries it is necessary to cover the soil with dry material to keep the soil moisture.

Method-3:

Also seeds can be used to plant bamboo, but bamboo bloom rarely and it is therefore difficult to get seeds.

The bamboo seeds should be collected on time. Collecting monopodial bamboo seeds are different than collecting sympodial bamboo seeds.

The seeds should be collected before the seeds fall from the tree.

A way to collect seeds from small bamboo trees is by laying cloth beneath the tree, and then shaking the tree.

Seeds can be collected from tall trees, after the trees have been cut down.

Because of the differences in species, some bamboo species grow many and some few seeds. Usually it is difficult to find a lot of seeds from the species with few seeds. The seeds should be planted right away. If the seeds are kept for a long time, they lose ability to grow. Some species have a lot of seeds and germinate if not collected on time.

When planting bamboo from seeds, the first and second year their shaped like a group of clumping bamboo.

The third year they change and the root system are recognized. The third year the diameter is around 0,7cm and the height is 1- 2 meter.

After the third year the bamboos can be planted outside.

PROPAGATION OF SYMPODIAL BAMBOO

Rhizome, culm and branches are used for propagation.

Before bamboo is propagated one need to know what it should be used for. When used for paper making or house building, method A or B are the best methods, for hand craft method C.

Method A

Using culm:

Spring is an ideal time to plant bamboos. A good young bamboo culm with buds should

be chosen for the propagation. Using the culm for propagation is the best method and fastest method.

1- Another way to propagate is to cut a one or two year old bamboo culm in many parts, leaving one or two nodes, and planting them diagonally or horizontally, also can plant them vertically. When new shoots grow, it is important to add nutrition for them to grow well. Also pay attention to any weeds or insect attack.

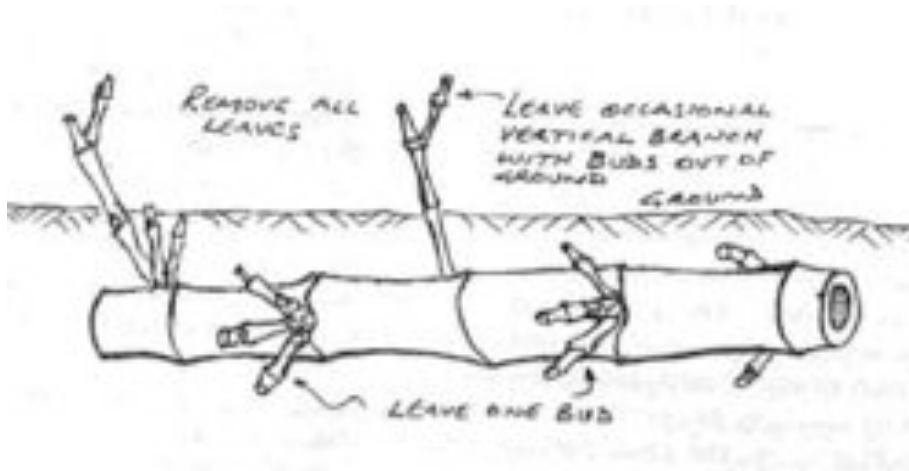


Figure 4-1. Culm cutting for propagation (Cusack 1997).

The disadvantages for using culm is laborious compare to propagating branches.

2- A one or two-year-old bamboo culm with many nodes can be used (Figure 4-2). The culm is placed into the soil and covered by soil. After a short time the nodes will grow roots, and new small shoots will emerge from the soil. The diameter of the shoots is small the first years and will increase in size every year.

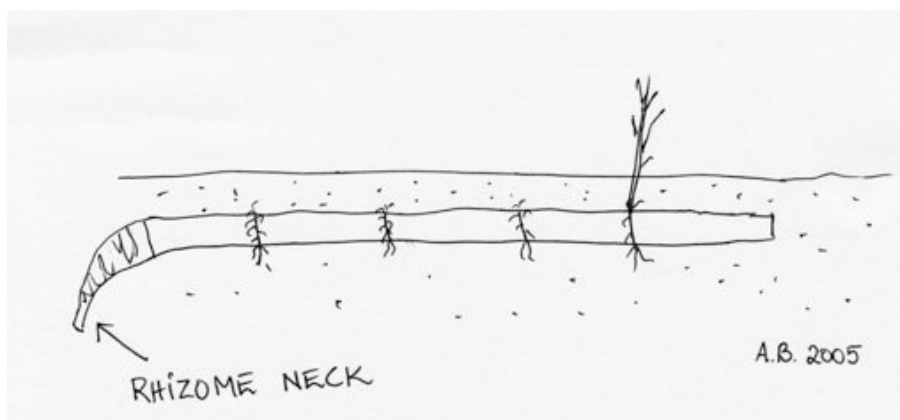


Figure 4-2. A young bamboo culm with many nodes (Badrkhan 2005).

Some species cannot grow roots around the nodes, and can therefore not be propagated in this way.

3-The culms are propagated as in nr. 2, but not cut from the clumps. The young culm is bended and placed it in a 5 cm deep trench and covered with soil. Then we add water and dry grass to keep the soil moisture and also protect it from the sun.

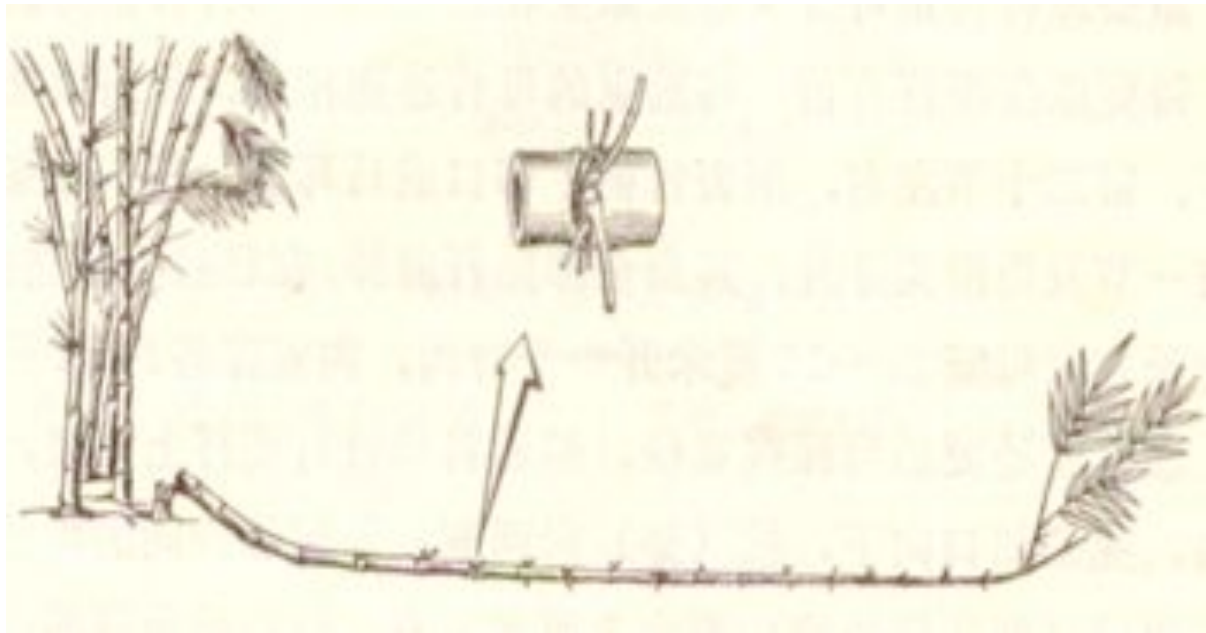


Figure 4-3. Propagating bamboo culm by bending it. The arrow shows a node with small branches (Chinese text book).

Method B

Using the bamboo rhizome:

On a rhizome there are many buds and these will also grow fast to new bamboo shoots. This method is also very fast for the bamboos to grow into big shoots.

Only the rhizome is cut and used to propagate. As it has many buds, the buds will grow into new shoots in a matter of a short time.

Method C

Using branches:

Cutting is a method that is used on branches. Usually it is done in spring, which is the best time for the buds to grow.

Bamboo branches grow in a bunch and usually are many. One or two branches are the most dominant having the biggest diameter.

Here on this picture we can see that there is one major dominated branch, two lesser dominated and the rest are small.

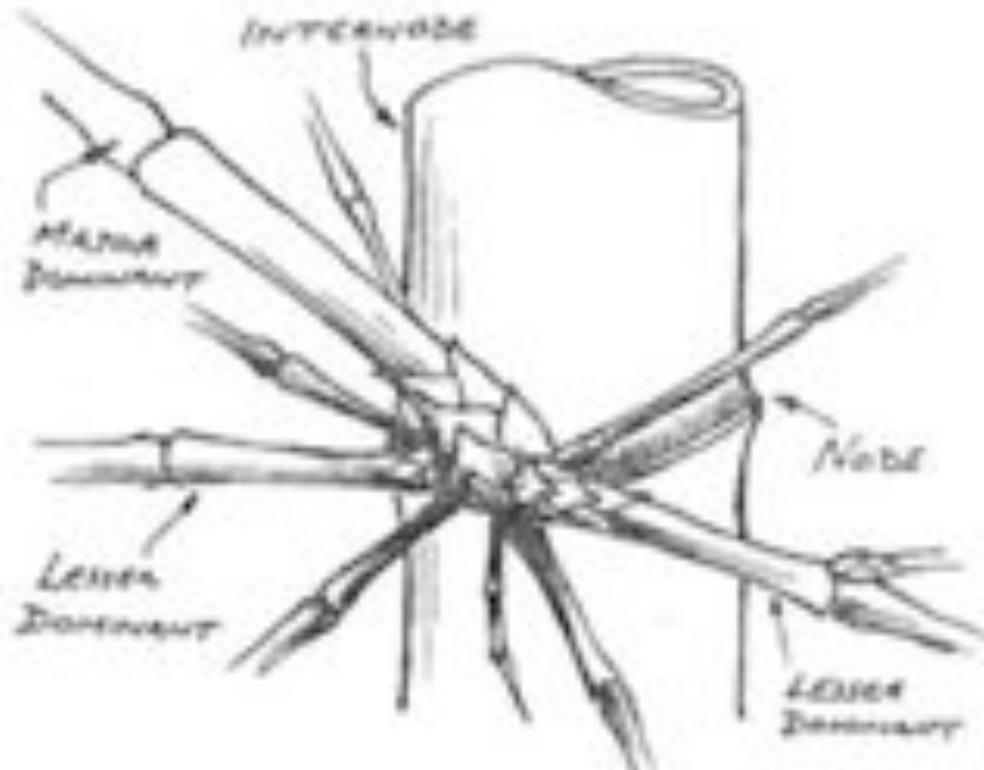


Figure 4-4. Dominant branch structure (Chinese textbook).

When the branch is used for propagation, it should be pulled, not cut, from the culm. This method must be done carefully, as it can damage the node (Figure 4-4).

It is also important to trim the branch before planting them in soil. If they are not trimmed, the other vegetative growth may steal water and nutrition that the branch will need in the beginning face of growth.

The first years the diameter of the branch is small, after three to five years the diameter becomes larger. (Gu pers. comm.)

HARVESTING BAMBOO

When harvesting bamboo, the shoots should be cut to reproduce more shoots. Sympodial bamboo (clumping rhizome type) is harvested differently from Monopodial bamboo (running rhizome type) shoots.

Harvesting monopodial bamboo shoot

Monopodial bamboo shoots are harvested below ground at the base of the young shoot

(Figure 5-1).

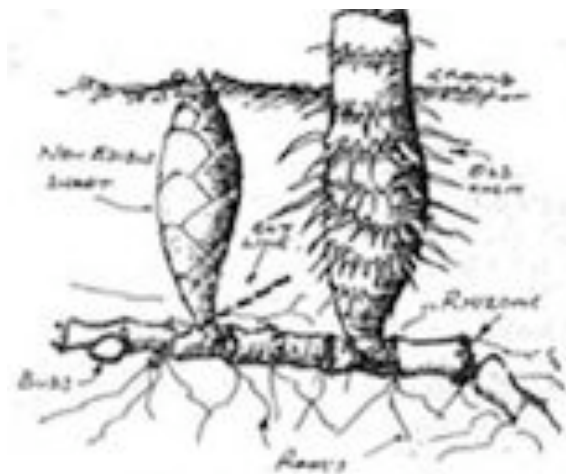


Figure 5-2. Monopodial bamboo shoots below the ground (Cusack 1997).

Harvesting Sympodial bamboo

The Sympodial bamboo rhizome has eight buds that are the very source of new bamboo shoots. When harvesting clumping bamboo, the shoot top is cut leaving some of the buds to grow into new shoots (Figure 5-3). The rest of the shoot will grow new roots and be able to feed the new shoots with nutrition.

There are buds on both sides of the rhizome. The two buds on each side closest to the rhizome neck are referred to as buds nr.1, the two next as bud nr.2 and so on.

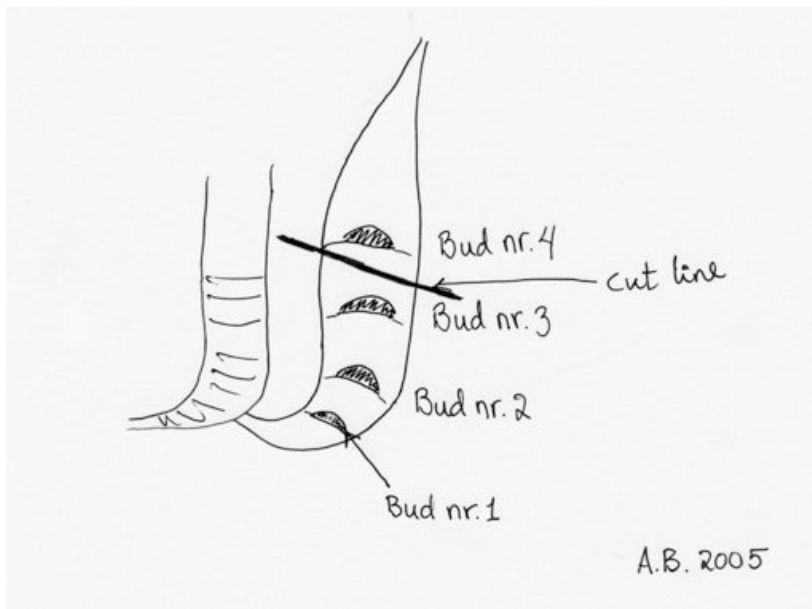


Figure 5-3. Cutting sympodial bamboo shoot (Badrkhan 2005).

When harvesting the shoot, the cut line is usually above bud nr.3 (Figure 5-3). Bud nr.3 start growing and is harvested for eating.

Every fourth year the oldest culms (the grandmother culms) should be cut from the clumping rhizome by 40 cm above ground level, to be used for accumulating rain water. They have already used up all their buds, and have no use for regenerating new plants.



Figure 5-4. Bamboo plantation wrongly Managed (Photo: Badrkhan 2005).

Figure 5-4. shows an example from a farmer in China who was managing his bamboo wrongly. He cut the mother bamboo instead of the grandmother bamboo and damaged the young bamboos. They lost their source of nutrition and became yellow and lost the ability to grow branches. All the bamboo he had planted where yellow and without branches.

According to professor Gu there was still hope for the bamboo plantation.

He advised the farmer to cut the bamboos to cut the grandmother bamboos instead of the mother bamboos, the next year they would grow normal.

MANAGEMENT OF BAMBOO

Bamboo is a plant that can grow and reproduce itself without any management, but they will not look very good.

Bamboos growing in the wild often take over the forest. In China they are called bamboo sea forest.

Since bamboo grow fast, seedling from tissue culture can be used for producing bamboo plantation.

Referring to the book *Physiology of Bamboo* (Shanmughavel & Francis 2001) the management of bamboo plantation should be in the following way:

- A nursery area of 10 * 5m should be prepared in the field and filled with a mixture of sand and soil (3:1).
- The seedlings may be taken out from the polythene bags when they are about 7cm in height. About 25 to 30 seedlings can be planted in 1 m² of raised nursery bed.
- Watering should be done 2-3 times a day and care should be taken to avoid over saturation.
- The seedlings should be protected from the sun by providing shade with thatch.
- The seedlings in the nursery can be removed carefully and taken to the field to be transplanted. There it can be planted at 6 * 6 cm spacing with 277 seedlings ha⁻¹.
- The transplanted seedlings need to be watered every 2 hours regularly in the morning and evening.
- Weeding should be done as and when required.
- After 1 year the plantation should be irrigated at 15 day intervals. Care should be taken to avoid water logging. The plantation should be protected and taken care.

Fertilizing Bamboo

The bamboo should be fertilized two to three times in a year.

The first time the bamboo is fertilized chemical fertilizers are used. They are fertilized before they start their vegetative growth, which is in spring. This way the new branches and leaves will get enough nutrition to grow better and stronger.

Also before the shoots start growing they are fertilized.

The second time in a year bamboo is fertilized organic manure is used. The amount of fertilizer depends on how many bamboo culms grow in a clump. For example 1 kg urea is enough for one group of clumping bamboo.

Nitrogen is the most important macro nutrition for good bamboo growth. The other macro and micro nutrition are not so very important for bamboo plants (Gu pers. comm.).

Insect attack

Insects attack the soft parts of the bamboo plant, like shoot or the tree tops. The branches and leaves are also attacked (Figure 6-1 and 2).



Figure 6-1. Insects attacking bamboo shoot (Photo: Badrkhan 2005).

There are many different types of insects attacking bamboo, but little is known about the insects and the publications are in Chinese.



Figure 6-2. Aphids on bamboos (Photo: Badrkhan 2005).

UTILIZATION

The use of the bamboo is very advanced in China. There are many bamboo factories producing bamboo products.

The bamboo specie and its behavior have a great importance to the product that is produced.

The bamboo can be used for:

- Shoot: for food
- Culms: for several of things like building, construction, paper, clothes, charcoal aso.
- Rhizome: for art
- Branches: for several things.

The use of Bamboo depends on the age:

- <30 days it is good for eating
- 6-9 months for baskets
- 2-3 years for bamboo boards or laminations
- 3-6 years for construction
- 6< years old bamboo loses its strength

Bamboo for construction

Bamboo for construction should be cut right after new shoots have started to grow, because the plant has given all its starch to the new culm. It is important to cut bamboo just above the node at the base.

The age of the culm is very important to know in order to select culms strong enough for bamboo construction. One year old bamboo is an emerald color with the sheaths just beginning to fall off.

Bamboo 2-3 years old has white spots on the culm, indicating the beginning of lichens. At 5-6 years these lichens can be clearly seen. Branches also tell the age of a bamboo plant. Every year each culm of bamboo loses its branches that are replaced with new branches. Usually insects attack the young bamboo. There are also some insects attacking the old bamboo from the interior and these can be difficult to detect.

There are some limitations of the use of bamboo in construction. The starchy interior is attractive to insects.

For longer lasting structures it is important to treat bamboo against rot and insects. In the Permaculture center in Senegal, we kept the bamboo for many days in saltwater before using them for building. This was done to protect the bamboo against insects attacking the interior (pers. exp.).

There are many methods of treating bamboo, like using chemicals. Adams (2005) mentioned an example of treating bamboo.

A solution of 3-10% of half borax and half boric acid is forced through bamboo using an air compressor to create 20-30 lb of pressure. The bamboo is left on a slight incline with the base closest to the tank (though it is also possible to do it in the other direction) and the chemicals gradually move through the vascular system. Basically to avoid problems it is important that the bamboo is dry before used in construction.

Structural Characteristics of Bamboo

Bamboo is a unique plant because it is strong in both tension and compression. The tensile strength remains the same throughout the age of the bamboo, while compressive strength increases, as it gets older.

To utilize bamboo to its best capabilities, there are some conditions that are extremely important to the plant. Bamboos grown on slopes are much stronger than if bamboo grown in valleys, and bamboos grown in poor dry soils are more solid than those grown in rich soils.

Bamboo has a slick waterproof coating, which is why it cannot be painted. However, this coating allows bamboo to be used as water pipes (collecting water).

As bamboo is extremely flexible from 6-12 months of age, it can be used to create a number of curving forms. But also methods are used to bend bamboo, like steaming the bamboo before making furniture (Adams 2005).

Bamboo is like a holy plant in China and also in Asia. It is a plant that has many benefits.



Figure 7-1. Paper factory in Fujian province in China (Photo: Badrkhan 2005).

Bamboo is mainly used for paper in China and the bamboo paper technology of China is very advanced.

There are still some small factories left producing bamboo paper like in the old fashion way, but they are few.



Figure 7-2. Plywood and furniture factory (Photo: Badrkhan 2005).



Figure 7-3. Factory producing charcoal and decorative products (Photo: Badrkhan 2005).

Bamboo mats are weaved; these mats are pressed together by a pressing machine, which results with thin bamboo boards (figure 7-4), and these boards are used in foundation buildings to make the foundation much stronger. They are often used in foundation of bridges.



Figure 7-4. Bamboo boards used in foundations (Photo: Badrkhan 2005).

There are many Bamboo weaving factories in China. Weaving with bamboo is one of many art techniques used in China. The weaving factory in Fujian is specialized in weaving bamboo sculptures (figure 7-6, 7) and conference tables (figure 7-5).



Figure 7-5. Weaved conference table (Photo: Badrkhan 2005).



Figure 7-6. Weaved sculpture of an elephant made from bamboo (Photo: Badrkhan 2005).



Figure 7-7. Basket weaved made from bamboo (Photo: Badrkhan 2005).

Bamboo used for food

Bamboo shoots are the young growth of bamboo and are harvested before they reach 30 cm (1 foot) in height, generally before they are two weeks old.

The young shoots are crispy and tender like asparagus and are widely used in Asian cooking. Bamboo shoots are commonly available in cans, though fresh bamboo shoots taste much better.

Nutritional Values

Bamboo shoots are low in calories and fat, containing only 14 calories and 0.5 g fat per half-cup serving. The same size serving also provides 2.5 g fiber, about one-tenth of the recommended daily amount.

Bamboo shoots are also rich in potassium: one cup contains 640 mg of potassium (18% of the recommended daily amount) which plays an important role in maintaining normal blood pressure and heart rate.

Storage

Fresh bamboo shoots can be stored for up to two weeks in the refrigerator. Avoid keeping them for longer periods or exposing them to sunlight to prevent them from becoming bitter.

Cooking Tips

Fresh bamboo shoots must be cleaned and cooked before eating. Raw, they are bitter and difficult to digest. First cut off the root ends, remove the tough outer leaves (the more tender leaves are edible, however) and pare away any tough fibrous sections before cooking. Slice the bamboo against the grain into 3 mm (1/8") slices. Very tender shoots can be sliced in any fashion.

Drop into boiling water and cook for about 20 minutes uncovered, to allow bitter substances in the bamboo to dissipate. Bamboo shoots that are still bitter after cooking can be given a second cooking in fresh water for approximately 5 minutes longer. To microwave bamboo shoots, place them in a shallow pan of water and cook uncovered for four minutes. Bamboo shoots should remain slightly crisp once cooked (Anon. 2005).

Concluding remarks

Bamboo has been used for many generations in China and can also be used in the west. Since bamboo is a fast growing plant, it can be used in the industry without any danger of being eradicated. Bamboo could be a niche plant in the market and can be used to produce various products.

In this term paper the focus was basically about general information about bamboo and how to grow bamboo. I have not immersed in the physiology and the biochemical process

in bamboo, since it needs a deeper knowledge and understanding, which I am going to continue later on in my studies.

Bamboo growing in warm climates is very different than bamboo growing in the cold. I have focused on bamboos growing in warm climates. The utilization of bamboo is just as important as learning about the bamboo plant. That is why I have emphasized on the utilization. If one does not know how to use bamboo, the plant becomes useless. That is why it is necessary to inform about the use. People in China used bamboo for many things. I hope this knowledge will develop in the world and explore the benefits of bamboo.

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