STUDIES ON MULTIPLICATION OF BAMBOO BY DIFFERENT GROWTH TYPES OF BAMBOO RHIZOMES

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At present, varieties of bamboo belonging to approximately 50 genus and 700 species cover a total of 14 million hectares of land throughout the world. However, about 80 per cent of that area is distributed in the Southeast Asian tropical regions while the remainder grows sporadically in other countries. Temperature restrictions must be ascribed to the absence of bamboo species growing naturally in the European countries.

In forestry, bamboos are generally considered as minor forest products but are valuable materials for use in agricultural or fisheries goods, furniture, interior decoration and various handicrafts. Therefore, bamboo is one of the indispensable materials in human life. Most of the resources used in pulp making in the tropical regions are broad-leaved trees (: hardwood) and the pulp and paper derived from these materials are weak in tensile and bursting strength, etc. because the fiber length is less than the fiber width. Therefore, bamboos are much more useful as pulp resources because tropical bamboos have longer fibers than needle-leaved trees (: softwood). In the past twenty years, more practical use has been made of bamboo and more than several thousand hectares of bamboo forests have been afforested in Mainland China. Also, Latin American countries such as Nicaragua and Colombia have begun to show greater interest in the plantation of bamboo.

Under these circumstances, the factors relating to the multiplication of bamboo planting stock for the fundamental purpose of afforestation of bamboo can be defined as follows:

Growth types of bamboo rhizomes and distribution of bamboo

Bamboo is generally capable of propagating asexually in the form of buds growing between rhizomes and culms. Accordingly, the propagation forms of bamboos which are distributed throughout the world are classified into two types. The first type is the non clump-forming type which includes *Phyllostachys* and *Semiarundinaria* genera distributed mainly in temperate and subtropical regions such as Japan, Korea, the centre of Mainland China, some areas in Taiwan and the highlands of the tropical regions. This type of bamboo is characterized by monopodial rhizomes and culms; some buds of the nodes of the rhizome protrude through the earth every year to become the culm, but the other buds at the apex of the rhizomes become new rhizomes creeping underground, so that bamboo culms emerge sporadically and are widely spaced. Most bamboos of this type are erect and the clear length is generally high. The other type is the clump-forming type. Bamboo species like *Bambusa, Dendrocalamus* and *Schizostachyum* genera, which grow in the tropical regions, belong to this type. Characteristic of this type of bamboo is the fact that the larger buds at the lower portion of the culm located under the ground surface sprout directly above the ground and the sprouting grows into culms, forming a clump of culms with short rhizomes. The sprouting period of this type is much longer than that of the non clump-forming type.

Ecological distribution of these two types of bamboo clearly relates to the annual precipitation and temperature in the area where they grow. Specifically, more than 1,000 mm of annual precipitation is needed for the growth of bamboo and temperature is related to this premise. In general, high temperatures accelerate the growth of bamboo and low temperatures inhibit it. To this effect, representative weather stations which recorded more than 1,000 mm in annual precipitation overlapped with stations which recorded a mean temperature of more than 10°C in the

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coldest month of the year in order to indicate those stations in which both conditions were met. As a result, the relationship between the type of growth of bamboo rhizomes and temperature clearly coincides with the distribution of actual bamboo forests. The clump-forming type of bamboo grows mainly in places where the temperature is higher than 20°C, and where the altitude is less than 100 meters above the sea level. Furthermore, only the clump-forming type of bamboo grows in places where the temperature is higher than 25°C. Non clump-forming types of bamboo very seldom grow in areas with a temperature of 20°C or thereabout. On the other hand, the non clump-forming types of bamboo grow naturally in areas higher than 1,000 meters above sea level. In the range of 10°C—20°C, clump-forming bamboos grow within regions with a temperature of 20°C and the non clump-forming types of bamboo may grow within regions with a temperature of 10°C. Only the non clump-forming types of bamboo grow in regions where the temperature is below 10°C.

Consequently, it is necessary to use that method of multiplication intended for non clump-forming types of bamboo growing around the temperate and subtropical regions, though both methods of multiplication are necessary for clump- and non clump-forming types of bamboo which grow at different altitudes in the tropical regions.

There are two methods of bamboo multiplication. One is the asexual propagation such as rhizome cutting (; offset planting), culm cutting, layering and grafting. The other is the sexual propagation by use of seeds gathered after flowering. As the genetic quality of the mother bamboo is inherited, in the case of asexual propagation, that of the successive generations of bamboos is ensured and poses no problem in the selection of planting materials. Accordingly, multiplication of the non clump-forming types of bamboo is usually affected by some method of offset planting. However, offset planting requires very hard work in digging up the rhizome and another drawback of this method is the risk of impairing the health, and vigour and thereby hurting the roots and buds of the mother plant. In particular, in clump-forming bamboos there is not a sharp distinction between the rhizome and the culm. Furthermore, as new culms propagate successive culms, mother bamboos are more badly damaged as compared to the non clump-forming types, and the root system may be hurt by offset planting. This is not a good method for tropical bamboo because it is limited to bud removal off the new bamboo. The method of culm cutting has been subject to experiments using different soils and different ways of water spraying but rooting by cuttings of non clump-forming types of bamboo has not been successful in Japan. On the other hand, although each bamboo species shows a different ratio of rooting the clump-forming types of bamboo generally take root easily.

The layering method was attempted with clump-forming types of bamboo, but the use of cuttings was found to be better and easier. Grafting which is also a method of asexual propagation of bamboo can not be applied.

As a result, offset planting is widely used in propagating bamboos of the non clump-forming type because rooting is not possible by applying culm cutting. On the other hand culm cutting is used in propagating bamboo of clump-forming type because the rooting rate of this type of bamboo is higher and more accurate by applying the culm cutting method than by applying offset planting.

Moreover, the use of seedlings in sexual propagation of bamboo can be applied to any type of bamboo. However, this method requires flowering and production of seeds by the mother plant.

Multiplication by offset planting for non clump-forming types of bamboo

1 Selection of rhizome

Each culm which belongs to the non clump-forming type of bamboo forests is fairly recognizable by the difference in culm diameter. The result of an investigation carried out in a *Phyllostachys bambusoides* grove, for instance, showed that the diameter of culms in a clone varied from 4 to 13 cm. This is due to the fact that the apical part of the rhizome or a front bud of a year old rhizome generally develops into a new rhizome every year, and the rhizome system consists of rhizomes of different ages, from about 1 to 10 years of age in a clone. Thus, rhizomes of different ages are connected in a clone, and, except for the one-year-old rhizome portions, the shoots grow from these

rhizomes of different ages. On the contrary, older rhizomes reduce the vigor of buds and the shoots also do not grow taller.

Hence, culm which grows from younger rhizomes will become bigger and taller. Furthermore, if rhizomes of the same age are used, the rhizomes having larger diameters will develop culms with larger diameters and, bamboo species which grew from rhizomes with large diameters live longer and are more vigorous for a longer period of time. Because of this, 2-year-old rhizomes of *Pleioblastus pubescens* develop larger diameter culms, while in *Phyllostachys bambusoides*, 3-year-old rhizomes are of better quality than culms of any other age.

These findings proved that the planting materials for offsets have to be selected among 2-to 3-year-old rhizomes showing a large number of fibrous roots, golden yellowish buds and rhizome sheaths which enable to identify the age of the rhizome.

2 Length of rhizome

Bamboo shoots grow more easily when longer rhizomes are used as planting materials because the longer rhizomes contain more nutrients. However, as the digging of rhizomes which are creeping underground is very difficult, it is necessary to determine the minimum length of the rhizome needed for the growth of the culm.

In general, bamboo species which have a culm of larger diameter require longer rhizomes, the length being about five times the basal girth of the culm. On the other hand, as the length changes whether or not the culm is attached, if bamboo rhizomes are planted without the culm, at least 1 meter of rhizome is needed to grow a mature bamboo shoot of *P. bambusoides* while 2 meters of rhizome are needed for *P. pubescens*. However, in the case of rhizomes with culm the ratio of survival is increased because assimilation by leaves is carried out. Because the nutrients which are released from the culm to the rhizome are always transported in the direction of the growth of the rhizome, the basal part of the rhizome is preferable to the center when it comes to the nutrition of the portion of a culm which is attached on the rhizome. Also the rhizome should be cut carefully with a saw.

3 Season for digging and planting

Elongation of rhizomes on non clump-forming types of bamboo begins about 2 or 3 months after the growth of the culm shoot and continues for approximately 3 months.

During this period, the nutrients which are stored within the rhizomes are absorbed in the process of growth of the new rhizome and are finally used up by the time the growth is completed. Therefore, offset materials should not be extracted during this period but rather when the rhizome will again contain nutrients after the growth of the rhizome is completed.

Whenever rhizomes are dug up with the culm, the upper part of the culm and its branches are removed, leaving a portion consisting of several nodes and their branches, so as to protect them from the wind and to reduce transpiration by the leaves.

The optimum months for planting in the northern regions are February and March and in the southern areas August and September. The best time for planting is when the buds on the rhizome show a slight swelling.

Multiplication by culm cutting for clump-forming types of bamboo

Culm cuttings generally need ample water in the nursery bed. During the dry season, irrigation is necessary to increase the water supply. As it is important to determine the best method of cutting, a cutting experiment was conducted in the Philippines using unsplit culm cutting of *Bambusa vulgaris*.

1 Method of cutting

One of the most important factors to consider in an effective method of cutting is the ease of water absorption through the cut portion of the material. Since this involves a wide range of in-

vestigations, a preliminary observation was conducted on *B. vulgaris* using three trials. Each trial consisted of a different treatment relating to the position of planting, and application of water and soil at the upper and basal hollow portions of the cutting materials, respectively.

The best method of cutting was to lay horizontally under the ground at about 20 cm. in depth, a section of culm having one node at its center, with wet soil applied in the basal hollow portion of the cutting, so as to protect the nodes from exposure to extreme conditions.

2 Selection of culm

Observations of the results were based on the following materials; (1) culms that developed just after branch elongation, and (2) six months after culm elongation, (3) one-year-old culm, and (4) two-year-old culm. The results tended to show that samples taken form a 6-month-old culm achieved the best growth rate because the branches and leaves were already fully developed.

If the supply of materials is limited, the selected culm is fully utilized, but if the supply is abundant those of the best quality are selected. The materials selected from the different portions should be of better quality than the original mother culm. Cutting materials taken from the butt portion of the culm were found to achieve a better growth rate than those taken from the middle portion and apex of *Bambusa vulgaris* and *Dendrocalamus strictus*. Samples from the middle portion of the culm showed adequate growth for *B. arundinacea* and *B. blumeana* while the apex of the culm did not appear to be a suitable material in most species.

3 Period for collecting samples

The period for the growth of tropical bamboos depends on the time of development during the wet season. A young culm capable of producing rhizomes, develops from 3 to 4 shoots during one growth period. Growth duration of the shoots that emerged early in the wet season was shorter than the period required for those which emerged later in the wet season, and culms which grew early in the wet season were longer than those which developed in the latter part of the wet season. The results are directly related to the amount of stored nutrients in the bamboos. Thus, the culm which grows in the latter part of the wet season and which has a larger diameter and a long internode is suitable as cutting material.

Multiplication by seedlings

In general, bamboos can be regenerated by an asexual method of propagation. However, sexual propagation by seeds is also feasible although not quite as practical due to the unusually prolonged flowering cycles, in most cases. An interesting and curious phenomenon about bamboos is that some species generally die soon or one year after flowering. Other species survive but their vegetative growth slows down during flowering.

Bamboo flowering can be classified into two types based on the extent of flowering per unit area. The first type involves wide areas, where in the non clump-forming type of bamboo all culms are flowering, or where in the clump-forming type of bamboo one clump of bamboo is uniformly flowering. The other type is represented by sporadic flowering in a non clump-forming type of bamboo forest, or by the presence of flowering on one culm in the clump. Seeds can be collected from almost all bamboo species, but some species are more productive than others.

The seeds are sown in nurseries or flower-pots. Seeds germinate two or three weeks after sowing, and then grow new culms every year. For several years, however, newly grown culms are slender, so that normal culms can not be harvested before 10 years after sowing seeds in the case of the non clump-forming type of bamboo. On the other hand, the clump-forming type of bamboo can be harvested a few years earlier.

Propagation after planting

What kind of method should be used for multiplication of bamboo, to enable new culms to grow gradually one after the other, as it is known that clump-forming types of bamboo generally grow

faster than the non clump-forming type?

The period required for culm harvesting is about 10 years even if 300 pieces of rhizomes are planted by offset of non clump-forming type of bamboo, because rhizomes elongate 1 to 3 meters a year and new culms sprout one year later than the growth of rhizomes. Culm cutting by clump-forming type of bamboo can be harvested 5 years after planting in the field. Harvesting of seedlings of non clump-forming type of bamboo requires 10 to 15 years while that of clump-forming type takes only 10 years.

Discussion

Ramilo, V. (The Philippines): In a given area in time and for a certain species of bamboo does sexual or asexual propagation give rise to high yields?

Answer: Asexual propagation gives rise to higher yields than sexual propagation.

Sato, T. (Japan): Is there any means, physical or chemical to promote or stimulate flowering and fruiting of bamboos?

Answer: Fertilizers do. Gibberellin does not stimulate nor promote flowering and fruiting of bamboos. In Japan small bamboos, unlike large ones, produce many seeds. Tropical bamboos on the other hand also produce many seeds.

Wawan K. (Indonesia): What kinds of bamboos would be best suited to Indonesia?

Answer: I would recommend *Bambusa vulgaris* for the production of handicraft and paper resources. This species can grow as pure stand or mixed with other tree species. Pure bamboo forests enable to get higher production per unit area.

Liew T. C. (Malaysia): Are there any edible bamboo species that can be grown in Sabah? If so, could planting materials be exported to Sabah for research purposes?

Answer: *P. pubescens* and *P. bambusoides var. aurea* could grow in Sabah at high elevations (1,500 m above sea level). Planting stock cannot be sent to Malaysia owing to quarantine regulations.