Bamboo Research in Asia

Organized by the International Development Research Centre and the International Union of Forestry Research Organizations

Gilles Lessard and Amy Chouinard

Workshop
Singapore
1980
The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in five sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences; and communications. IDRC is financed solely by the Parliament of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

©1980 International Development Research Centre
Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa

Lessard, G.
Chouinard, A.
IDRC, Ottawa CA
International Union of Forestry Research Organizations, Vienna AT


/IDRC publication/, /bamboo/, /South Asia/, /South East Asia/, /forestry research/ - /botany/, /classification/, /morphology/, /ecology/, /physical properties/, /geographic distribution/, /cultivation techniques/, /construction materials/, /musical instruments/, /conference report/, /list of participants/.


Microfiche edition available

The cover artwork, which has been reproduced throughout the book, is a line drawing based on a painting by Hui Nien, which has been used in several works on bamboo.
Bamboo Research in Asia

Proceedings of a workshop held in Singapore, 28–30 May 1980

Editors: Gilles Lessard and Amy Chouinard

Organized by the International Development Research Centre and the International Union of Forestry Research Organizations
Contents

Foreword 5
Participants 7
Research Needs and Priorities 9
Cooperative Activities 12
Country Reports 13
Bangladesh 15
India 19
Japan 47
China 57
Indonesia 63
Philippines 69
Sri Lanka 81
Thailand 85
Malaysia 91
Discussion Summary 96
Special Papers 97
Bamboos in the Asia-Pacific Region Y.M.L. Sharma 99
Bamboo Taxonomy in the Indo-Malesian Region Soejatmi Dransfield 121
Lessons from Past Studies on the Propagation of Bamboos S.M. Hasan 131
Propagation of Bamboos by Clonal Methods and by Seed
Ratan Lal Banik 139
Bamboo Cultivation Etsuo Uchimura 151
Anatomy of Bamboo W. Liese 161
Preservation of Bamboos W. Liese 165
The Mechanical Properties of Bamboo Used in Construction
Jules Janssen 173
Properties and Utilization of Philippine Erect Bamboos Francisco N.
Tamolang, Felipe R. Lopez, Jose A. Semana, Ricardo F. Casin, and Zenita
B. Espiloy 189
The Angklung and Other West Javanese Bamboo Musical Instruments
Elizabeth A. Widjaja 201
Lessons from Past Studies on the Propagation of Bamboos

S. M. Hasan

A number of papers on flowering habit, seeding cycle, propagation by seed, and vegetative methods of bamboos have been studied, and it has been found that a lot of information is available in bits and pieces. To date, no serious attempt has been made to analyze this information; this paper attempts such an analysis, concluding that various physiologic, genetic, and ecologic factors have made the study of seeding behaviour of bamboos very complex. It is suggested that a new area for research on this subject should be based on the use of seeds. Regional cooperation for the exchange of seeds and information will be necessary if such a program is to be comprehensive and successful. Seed-production areas need to be established from all natural and induced out-of-phase seedings and, where necessary, multiplied vegetatively. Such measures are likely to make seed available in bulk and more frequently.

In the field of vegetative propagation, well-differentiated tissues have been used almost exclusively in experiments – a fact that is probably responsible for the high degree of failures. Undifferentiated cells that are found in preexisting primordial structures in culm buds may be a useful material for future studies, which should employ the media and methods being applied in tissue-culture techniques.

The economic, ecologic, and silvicultural importance of bamboos in South and Southeast Asia is phenomenal. In this region, bamboos are widely distributed in forest areas and also cultivated in village groves. In many countries bamboo has become an integral part of the village economy and is extensively used for cheap housing and items for domestic and agricultural uses, including food and feed. Lately it is being extensively used for industrial purposes such as the manufacture of paper, rayon, cellophane, etc.

Concern about bamboo areas in the forest has arisen from the fact that in some countries they are being overexploited. The result has been what is regarded as the first stages in the annihilation of this important group of forest products. In the village groves mainly thick-walled bamboos, with limited local utility, are cultivated. These, however, would be highly useful for the pulp industry if the villagers were willing to feed such mills. Unfortunately, this is not always the case. The thin-walled species, which are more suitable for construction of cheap houses, are relatively difficult to propagate and are seldom cultivated; they abound in the inaccessible areas of forests and are the main raw material for the pulp mills. These facts have created a wide imbalance between production and utilization.

1Forest Consultant, Chittagong, Bangladesh.
The abundance of bamboo in South and Southeast Asia is probably responsible for the apathy toward its development. Concern usually comes only when a resource is completely lacking or is scarce. Some countries of this region have begun to feel the pinch of depleting stocks, whereas others are apathetic, and still others are engaged in wanton destruction of the resource because they are not aware of its utility and importance. The first step toward correcting the imbalance between production and utilization of bamboos is creating an awareness of the depleted stocks. Persons who have studied the economics of bamboos are convinced that the main impediment in the maximum utilization of this renewable resource is its propagation.

In the past, all studies on bamboos were made in natural stands, as it was thought that the world stocks of bamboos are sufficient to last perpetually. However, McClure (248) and I (137) have studied forests adjacent to human habitations and those exploited for industrial purposes and have found that the assumption of everlasting stocks of natural bamboos is not correct. Continued excessive cutting results in reduced yield of bamboos and, eventually, their extermination. Bamboo-growing areas have receded, and the process of recession, which probably ends in extermination, demands artificial restocking of the depleted areas.

Studies on the propagation of bamboos started in the last decade of the 19th century. In 1893 the Government of India issued a circular that has been incorporated in forest manuals in Bangladesh and elsewhere (7), setting out requirements for reporting all seedings of bamboos. Pathak (312) made the first attempt to propagate *Dendrocalamus strictus* by cuttings. Since then about 120 papers on flowering behaviour, 150 papers on seeding cycle, and about 40 papers on the results of propagation by seed have been published. Also about 80 papers on vegetative propagation of bamboos have been published. Some of the papers include information of far-reaching consequences, and, when the information from different sources is put together, it leads to some practical conclusions. Such compilations have been made earlier by Janzen (179) for seeding behaviour and McClure (244) for vegetative propagation. However, none of these attempts have resulted in a solution of the problem or in the establishment of a standard technology for raising bamboos artificially. At present, a different approach is being taken; it includes both seeding behaviour and vegetative propagation. A brief summary of the attempts and their analysis should help in the planning of future research programs on the propagation of bamboos.

**Propagation by Seed**

Possibilities of raising bamboo plantations from seed are limited because many bamboos produce seeds only two or three times a century. Most attempts in the past have concentrated on determining the seeding cycle. The hope was to be able to forecast seeding. The method was to record the seeding in forests and estimate the seeding cycle from past documents or from accounts by villagers nearby. Although considerable observations on the seeding of different species of bamboos have been made and reported, they have lacked information on the regions where flowering occurred and, thus, have done little to clarify the uncertainty about seeding cycles.

It has been possible, however, to determine the exact seeding cycle of species introduced into regions outside their natural habitat. Dutra (85) reported that *Bambusa arundinacea* was introduced in Brazil probably from an 1804 seeding in Coorg (India) and that it flowered in 1836, 1868, and 1899, giving a
seeding cycle of 31–32 years. Clement (72) reported that *Dendrocalamus strictus* was introduced in Cuba probably from a 1912 seeding in Gharwal (India) and that it flowered in 1956 — a seeding cycle of 44 years. Wang and Chen (459) reported that a plantation of *D. strictus* raised in 1922 in Taiwan from seed from Bihar (India) flowered in 1969 — a seeding cycle of 47 years. Bor (53) recorded that *Thyrsostachys oliveri*, planted in 1891 in Dehra Dun from seed from Burma, flowered in 1939 — a seeding cycle of 48 years. These are the only cases for which the exact seeding cycle (from seed to seed) is known. In the case of all other species, the information is rather speculative.

In natural stands, the question of seeding cycle is not as easy as it may appear because of the physiologic, genetic, and ecologic factors involved.

**Out-of-Phase Flowering**

From a study of the published work, it is clear that most bamboo species produce seed once in their lifetime; the event appears to be caused by an internal physiologic calendar that controls the length of the vegetative period. Variations occur, and they seem to be due to environmental factors that cause an accidental breakdown of the physiologic shield. The result is that the plant flowers at a different time from the original plant, but the length of the vegetative period remains unchanged. In 1978, I (142) suggested that in *Melocanna baccifera* there are a normal and a number of out-of-phase flowerings. The normal is gregarious flowering over large areas such as occurred during 1958–61 and has been reported from extensive areas in Assam (278, 279), Bangladesh (139), and Burma. Seeds from a few clumps, however, were collected in Bangladesh in 1974 and 1975, which is in the middle of the normal seeding cycle. In *Bambusa tulda* and *Dendrocalamus longispathus*, gregarious seeding of the nature of *M. baccifera* has not been reported, but sporadic flowering extending over an area of one-fourth to several hectares has been recorded in Bangladesh for a number of years in different regions. Prasad (323) has reported similar seedings in *B. tulda* for a number of years in different regions of Bangladesh and Burma. These variants may be considered varieties, as they behave similarly from generation to generation in respect to flowering. This factor makes a study of seeding habit in natural stands complicated.

**Flowering Habit**

With a few exceptions, grasses are characterized by semelparity; however, all grades of iteroparity have been reported in bamboos. For example, Gamble (104) and Rhind (339) recorded *B. lineata* as a regularly flowering species. In 1966, McClure (244) recorded that *B. tulidoides* flowered for more than 42 years before dying in Honduras and that *Arundinaria amabilis* and *Phyllostachys nidularia* flowered gregariously for more than 10 years before dying and gradually recovering from rhizomes. Bean (42) recorded the flowering of a few clumps of *A. simontii* for 14 years, the clumps dying every year but recovering from rhizomes. At the Forest Research Institute, Chittagong, partial flowering of some clumps for a few years and complete flowering of other clumps in 1 year before dying has been recorded for *B. glaucescens* and *D. longispathus*. The same phenomenon was reported by Mathauda (241) in the case of *D. strictus* from India. In *B. glaucescens*, *D. longispathus*, and *D. strictus* these different forms of flowering habits do exist. It is not clear whether they also occur in other species. Further systematic research on the subject is necessary. The causes of such variations have not been investigated but are probably inherent characteristics of the species.
Genetic Mutation

Long vegetative periods before flowering are not peculiar to bamboos, being rather a general dendroid character. All trees have a longer or shorter vegetative period before they begin to flower. Larsen (212) found that the age at which trees first flower is under genetic control. He observed that, in teak, flowering normally starts at age 8–10 years with considerable individual variation. Trees have been observed to flower at age 3 months, but a few used in genetic selection have not flowered by age 27 years. The variable length of the vegetative period prior to flowering is also common to bamboos, which are arborescent grasses. Changes in the length of the vegetative period and, hence, different seeding cycles, are probably due to genetic mutation.

From seeds of *Bambusa tulda* sown at the Forest Research Institute, Chittagong, a few 2–3-year-old seedlings flowered and produced seeds. Of 39 clumps raised from the seeds of these seedlings, 16 have behaved similarly to the mother plant, and the others have not yet flowered. It is too early to make any comments other than that the two groups are genetically different. From India, similarly, seeds were produced by 2–3-year-old seedlings of *Dendrocalamus strictus* (6, 47), but a follow up with the progeny has not been attempted. In *D. strictus*, three; in *B. arundinacea*, two; and in *Oxytenanthera abyssinica*, three seeding cycles appear to exist. For *D. strictus*, Kadambi (182) suggested a seeding cycle of 25 years in Mysore State (south India); Gupta (129) suggested a seeding cycle of 40 years from north India; and Mathauda (241), 65 years also in north India. Similarly for *B. arundinacea*, Nicholson (281) suggested a seeding cycle of 32 years in Orissa, and Blatter (51) suggested a seeding cycle of 45 years from Bombay State (south India). From East Africa, Fanshaw (97) suggested a seeding cycle of 7 and 21 years for *Oxytenanthera abyssinica* in Kenya and Adlard (3), 15 years in Malawi. Clumps raised in Brazil from seeds taken from Coorg gave a seeding cycle of 31–32 years for *B. arundinacea* (85). This cycle is the same as that suggested by Nicholson (281) for the clumps in Coorg. The actual seeding cycle for *D. strictus* obtained in Cuba (72) is very near that suggested by Gupta (129). The seed imported in Cuba was reported to be taken from Gharwal, and Gupta's suggestion is from seeding in Bihar. Thus, the bamboos in different regions appear genetically different. The genetic diversities occur in far-flung regions and can be taken as provenance. The variations are probably caused by genetic mutations due to geographic factors.

Natural Hybrids

Free hybridization between species produces forms of diverse nature. In my studies, I (135) found that seeds collected from natural stands of *D. longispathus* produced clumps that show variation in morphologic characters such as the culm sheaths, culm buds, branching habit of culm buds, presence or absence of supranodal ridge, and the time that leaves or branches regularly fall. I (136) also reported the occurrence of variation in clump forms and order of breaking of culm buds in different clumps in *B. polymorpha* raised from offsets and collected from different localities. In *B. arundinacea*, Bahadur et al. (26) found that seedlings showed right-handed and left-handed folding of the first leaf and that the left-handed ones grew faster. Kondas et al. (204) identified four different types of seedlings in *B. arundinacea*, which they called grassy, grassy erect, erect, and very erect. The erect and the very erect types were more vigorous and were faster-growing. The authors suggested that the shoot thickness and internode length could be used for selection purposes. The erect types accumulated dry matter more quickly than did the spreading types. Natural crosses between
species only occur when the flowering time of different species is the same — a rare occasion. Within a species, this is common. Variations that appear to be controlled genetically can be seen even while the clumps are growing; variations in seeding behaviour can only be seen when the clumps flower. When a species flowers, the variation in the nature of flowering and seeding cycle, etc., inherent in the clump, is expressed, and the individuals in a population behave differently depending on their distribution in the area. It is necessary to study and analyze the causes of variation in the progeny raised from seed.

Mixed Natural Stands

All natural stands are a mixture of species not only of diverse morphologic characters but also of different forms with different seeding behaviour. From the literature, it appears that sporadic flowering has been interpreted as a precursor to gregarious flowering. The ecoligic distribution of individuals is responsible for sporadic and gregarious flowering. Often large areas in natural stands have been seeded simultaneously and thus flower gregariously. Stands can be created artificially that will flower gregariously or sporadically.

In the past, all studies on seeding behaviour have been carried out in natural stands, which comprise genetically variable clumps and clumps from out-of-phase flowering with different seeding times. To get a correct picture, one must limit the variables, and at present, this means studying individual clumps and not the population. It is increasingly important to study the behaviour of progeny of seeds. Therefore, it is necessary to raise arboreta, gene banks, and seed stands. Gene banks should include not only morphologic variables but also variables with regard to seeding behaviour. Also, special seed-production areas consisting of varieties flowering at different times are needed so that seed may be made available more often and may be used for the raising of plantations at will. For this purpose regional cooperation for the exchange of seeds and other planting materials is necessary. In cases where the number of clumps is few and the quantity of seed produced is likely to be small, the progeny may be multiplied by vegetative propagation.

Vegetative Propagation

The most important limiting factor in the cultivation of bamboos is the difficulty of obtaining regeneration artificially. At present, some propagation is carried out by vegetative methods. In species with leptomorph rhizomes, which are found in temperate regions only, Oh and Aoh (290) found that planting rhizome cuttings, 40–50 cm long, 10 cm deep gave good results. This method has become the normal practice in Korea where 1000 rhizome cuttings are planted per hectare. In species with pachymorph rhizomes, which are commonly found in tropical and subtropical regions, offsets are used but are bulky, heavy, and difficult to handle and transport. Also, only a limited supply of the planting material needed for offsets is available per clump; therefore, this method is impractical for use in large plantation programs. In 1977, I (141) found that using branch cuttings instead of offsets overcame the difficulty of scarcity, bulk, and weight of planting material but that success in propagation was very limited. Early researchers, like Pathak (312), Lin (223), and Chinte (70), failed to draw a distinction between dicots and monocots, and they tried to use culm segments in somewhat the same way as these are used in sugarcane. Their observations were limited to a short period. When they observed the development of sprouts from the nodes, they all hastened to publish the results, classifying bamboos as easy to
propagate by culm segments. Similarly, Cabanday (61) tried ground- and air-layering of culms and culm buds and also reported good percentages of success in a few species. These studies have one major flaw in common: the researchers did not wait to see how the propagules fared after being planted in the field. If they had, they would have found that the propagules soon die. Clones do not become fieldworthy unless rhizomes have been formed and new shoots start emerging. Abeels (2), who tried branch cutting, came to the conclusion that as long as the swollen basal portion of the branch was present, the planting medium did not matter. McClure and Durand (249) pointed out that, in the matter of striking roots, the basal buds are slow to sprout and during this time the planted materials often die, with the result that the percentage of success is low. My studies (141) have shown that branch cuttings take 6–30 months to develop into good planting material. Roots may develop in 6–12 months, but the development of rhizome takes 12–36 months, and the planted material that fails to develop rhizome ultimately dies. In fact, the planting material continues to die until the rhizome develops. I also found that the use of humidity tents and sealed tins prolongs the life of the cuttings but does not improve the rooting. White (462) and Delgado (79) pointed out that root-promoting substances, at the normal concentrations, have no effect. Because of the difficulty of obtaining satisfactory results with or without root-promoting substances and because of the long period of waiting (30–36 months), none of the current vegetative methods can be said to be easy or economic.

An examination of the structure of the material used for experimentation indicates the reasons for the low percentage of success. My studies (141) have led me to conclude that the branches are miniature culms. The basal portion of both is swollen. In the case of culm the swelling is known as rhizome and in the case of branches it has been termed rhizomatous swelling of branch bases. The swollen bases of the branches are morphologically and, under certain conditions, physiologically similar to the rhizome, and they can be made to function like it as well. Both consist of well-differentiated tissues. There is no meristematic tissue except that in the buds. Porterfield (320) studied the morphology of growth in bamboos and concluded that the sheath primordia are the first appendages to emerge behind the apex of the growing point. Next to emerge are the primordia of the buds subtended by each sheath. The axis of the bamboo plant elongates principally during the “grand period of growth.” The elongation is effected by means of intercalary growth. The apex of the growing point is protected by many layers of overlapping sheaths. Recently, I (140) found that bamboo buds consist of primordial structures that are rhizome-like and have partly preformed sheaths attached to a meristematic band. This meristematic tissue represents the nodes and internodes of the branches only; the root primordia are borne outside. From any textbook of botany it can be learned that the process of differentiation of tissue and enlargement of cells consists of the formation of a vacuole; as the cell enlarges and the protoplasm spreads along the cell wall, the vacuole degenerates and the cell wall starts thickening. The cells, therefore, lose all potential to divide and only act as strengthening, conducting, or storage tissue. In most monocots, the meristematic activity is limited to set structures — mainly the bud. It does not spring up anywhere on the body of the plant. Once a tissue has been differentiated, it does not have tissue-adding properties, and, therefore, no new primordia for root and rhizome development are formed. The textbooks also indicate that the protoplasm is the active substance that, under the influence of environmental factors, produces biologically active chemicals responsible for initiating differentiation. Due to the absence of protoplasm in well-
differentiated tissue, no such activity takes place. The development of rhizome is dependent on the biologic condition of the buds on the rhizomatous swelling. These buds, being the softest part on bamboo culms, are easily attacked by insects and other organisms. All such buds are normally dead and do not develop.

It is clear that, for all practical purposes, different forms of the same material, that is, well-differentiated tissue, have been used, in trials to date, and for this reason the use of different media seems to have produced no effect on rooting. It is now time that the planting material be changed to undifferentiated cells. It is only the preexisting primordia or the primordial structures in the bud that are physiologically active and that can produce branches or other plant parts. The easy rooting of sugarcane is probably due to the presence of undifferentiated cells in the nodes even after the growth of the culms is complete. The media and the methods to be adopted should be similar to those used in tissue culture.

According to the findings of Porterfield (320), Tomar (421), McClure (244), and many other workers, it is clear that the shoot growth in grasses and particularly in bamboos, instead of being terminal, is intercalary. Venkatraman (456) published photographs that clearly show the elongation of internodes to be at the base. Except for the terminal bud of the rhizome and the rhizomatous swelling, there is no terminal bud and the growth in length is caused by elongation of the internodes. The growth of individual primordial structures starts from the centre of the cone-like structure and proceeds outward so that the smallest preformed sheath in the centre comes out first and becomes the topmost node and the largest outermost preformed sheath becomes the lowest node above the rhizomatous swelling of the branch. At first the meristematic activity is spread over the entire node; however, as the elongation of the cells goes on to form the internodes, the nodes are separated and the meristematic activity shrinks, ultimately being confined to the bud. No other part of the fully grown branch has this property. Cobin (1947) noted that some plants of B. textilis had an abundance of roots on the bases of the branches, a circumstance that he attributed to the poorly drained condition of the soil. In 1977, I(141) noted such rooting on some branches of other species that were growing in well-drained soils. Probably the rooting preceded the completed differentiation of the cells or resulted from some cells that remained undifferentiated. The sparse development of roots from the nodes of bamboos, under normal conditions, indicates that the number of undifferentiated cells is very low and, therefore, the striking of roots, even under favourable conditions such as those during experiments, is low. Probably the experimental material to be used in the future should be undifferentiated tissue or the primordial structures in the bud.

Concluding Remarks

In the past, all studies on seeding behaviour of bamboos have been made in natural stands, and, hence, even after 100 years of study, regeneration in bamboos is not clearly understood. In natural forests, a number of factors militate against controlled studies, including out-of-phase flowering; species with various grades of iteropary and others with semelpary; genetic mutations in respect of length of vegetative period prior to flowering; natural hybrids; and the ecologic distribution of diverse forms in the same area resulting in mixed stands. It is necessary to change the strategy of research. The seed must be used as a tool of research, and all seedings must be optimally utilized. The length of the
vegetative period has clearly emerged in bamboos raised as exotics from seeds. It is, therefore, necessary to establish research areas where all the species of economic importance can be planted from all the seedings that come to light. Meticulous records of the behaviour of individual clumps and their progenitors must be kept, and it is likely that regional cooperation for exchange of seeds and information is necessary for a successful program.

The seeding behaviour of bamboos indicates that it is possible to induce out-of-phase flowering. Research on this subject should produce new out-of-phase flowering strains that are at present nonexistent in nature. In the meantime, seed-production areas can be created with all natural out-of-phase seedings, and induced flowerings can make seed available every year.

This is a long, drawn-out process and, till such time as the fruits of the attempts are available, other methods will have to be used, including propagation with materials other than seeds. It is clear, from a brief review, that all known methods, except for tissue culture, have been tried without much success. My studies of culm buds (140) have shown that primordial structures in culm buds can be used in tissue-culture trials and need to be taken up at an early date.