# BAMBOO

## CULTURE and UTILIZATION in PUERTO RICO



CIRCULAR No. 29
Federal Experiment Station in Puerto Rico
U. S. DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Office of Experiment Stations

## FEDERAL EXPERIMENT STATION IN PUERTO RICO

**MAYAGUEZ, PUERTO RICO**

Administered by the Office of Experiment Stations

Agricultural Research Administration

United States Department of Agriculture

R. W. TRULLINGER, *Chief, Office of Experiment Stations*

---

### STATION STAFF

KENNETH A. BARTLETT, *Director.*
ARNAUD J. LOUSTALOT, *Assistant Director, Plant Physiologist.*
RICHARD H. HAGEMAN, *Chemist.*
CALEB PAGÁN CARLO, *Chemist.*
HAROLD K. PLANK, *Entomologist.*
EDWARD P. HUME, *Horticulturist.*
HAROLD F. WINTERS, *Horticulturist.*
HARRY E. WARMKE, *Plant Breeder.*
RUBÉN H. FREYRE, *Scientific Aid.*
CARMELO ALEMAR, *Administrative Assistant.*
HILDA J. CARRERO, *Clerk-Stenographer.*
JUANA F. CEDÓ, *Clerk-Stenographer.*
WILLIAM VARGAS, *Property Clerk.*
NARCISCO ALMEYDA, *Collaborating Agronomist.*[1]
HÉCTOR R. CIBES VIADÉ, *Collaborating Agronomist.*[1]
HECTOR J. CRUZADO, *Collaborating Agronomist.*[1]
ROBERTO FERRER DELGADO, *Collaborating Agronomist.*[1]
RAFAEL FERNANDEZ POL, *Collaborating Chemist.*[1]
PEDRO J. SEGUINOT, *Cooperating Laboratory Helper.*[1]
NILDA ACEVEDO, *Cooperating Clerk-Stenographer.*[1]
JULIA LÓPEZ, *Cooperating Clerk-Stenographer.*[1]
SUSANA RODRÍGUEZ, *Cooperating Clerk-Stenographer.*[1]
JOSÉ GONZÁLEZ, *Cooperating Farm Foreman.*[1]
ASTOR GONZÁLEZ, *Cooperating Librarian.*[1]
VICTORIA MALDONADO, *Cooperating Library Assistant.*[1]

COVER ILLUSTRATION.—*Bambusa textilis* 2 years of age.

---

[1] In cooperation with the Government of Puerto Rico.

FEDERAL EXPERIMENT STATION IN PUERTO RICO
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

CIRCULAR NO. 29

Washington, D. C. April 1948

# BAMBOO CULTURE AND UTILIZATION IN PUERTO RICO

By DAVID G. WHITE, *plant physiologist* [1] [2]

## CONTENTS



## INTRODUCTION

Studies of the culture and utilization of bamboo (*19*) [3] were started in 1934 at the Federal Experiment Station in Puerto Rico at the suggestion of the Honorable Blanton Winship, who was then Governor of Puerto Rico. Routine introductions representing 10 species of bamboo had been made previously by the station. In addition, a so-called "native" bamboo, *Bambusa vulgaris* Schrad. ex Wendl., had been introduced on the island some hundred or more years ago by the Spaniards. In recent years other bamboo species have been added regularly to the station collection, primarily through the cooperation of the Division of Plant Exploration and Introduction, Bureau of Plant Industry, Soils, and Agricultural Engineering of the United States Department of Agriculture. At present there are 30 species and varieties of bamboo established on the station grounds.

[1] Now with the United States Department of Agriculture Subtropical Fruit Field Station, Orlando, Fla.

[2] Appreciation for suggestions used in and detailed corrections of this circular is expressed to the following members of the U. S. Department of Agriculture: R. A. Young, collaborator, Bureau of Plant Industry, Soils, and Agricultural Engineering, and F. A. McClure, field service consultant on bamboo, Office of Foreign Agricultural Relations, who identified many of the species described as well as other species.

[3] Italic numbers in parentheses refer to Literature Cited, p. 33.

The distribution of clump divisions of tested species to farmers in Puerto Rico has been a regular practice by the station. During the period 1935–1946 more than 50,000 divisions were supplied. Many of these distributions were carried out in cooperation with Government agencies such as the Forest Service, the Agricultural Extension Service, and the Soil Conservation Service.

The distribution of bamboo divisions from the station has not been limited to Puerto Rico, however. Several Government agencies and private individuals in the Caribbean area and elsewhere have received planting material from the station. By the end of 1946 a total of 1,293 divisions had been sent to Antigua, Dominica, Jamaica, and Trinidad, of the British West Indies; the Dominican Republic; Ecuador; Haiti; Honduras; Nicaragua; Peru; United States; and the U. S. Virgin Islands. In many of these countries the culture of bamboo has been promoted as a result of the introductions furnished by this station.

Several industries utilizing bamboo for the manufacture of furniture, fishing rods, picture frames, lamps, ladies' handbags, and other miscellaneous articles have become established in Puerto Rico. Their establishment was fostered by the Puerto Rico Development Co., in cooperation with the station. Previously considerable effort was spent in developing improved techniques for the utilization of bamboo culms in a program sponsored by the Insular Government at the station for several years. In the last 3 years approximately 200,000 linear feet of bamboo culms has been supplied to industries and private individuals by the station.

**Types of bamboo.**—There are two general types of bamboo, which are defined as either "clump" or "running."

Those of the running type have a monopodial habit of rhizome development, i.e., the horizontal underground stems called rhizomes grow indefinitely in a horizontal position underground (fig. 1, *A*). In this type new culms arise from lateral buds of the rhizomes and form thickets of culms. Six species of running bamboo are established on the station grounds.

The majority of the species established at the station have been clump types. This type of bamboo develops rhizomes which grow a short distance laterally and then turn upward and form new culms. Since the new culms arise relatively close to parent culms, a number of the culms form a clump (fig. 1, *B*). A list of the different species and varieties of bamboo established on the station grounds is presented in table 1 (*4*, *5*, *6*, *11*, *13*).

Several species of clump bamboo which will be discussed later have certain advantages over many other species. The clump type of bamboo does not spread rapidly so that its restriction is not a problem as often occurs with the running type of bamboo. The most useful species are not thorny and have rather straight culms with long internodes and relatively few lateral branches. Their culms are durable and adapted for numerous construction and manufacturing purposes. Also, the culms of some species are more or less naturally resistant to infestation by the bambo powder-post beetle, *Dinoderus minutus* (F.), when properly cured. It is possible that treatments may be developed in the future which will make culms of any bamboo resistant to the

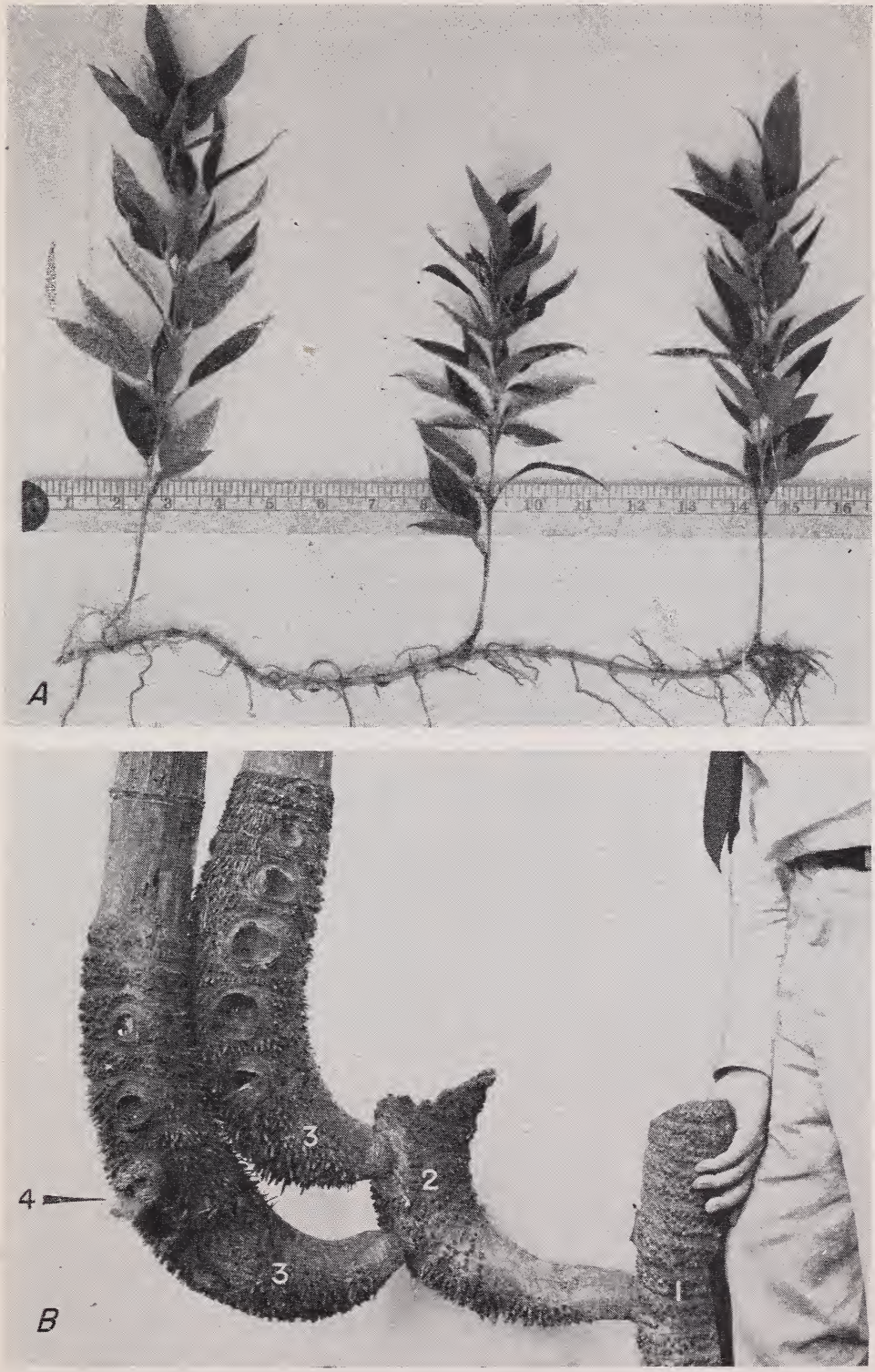


FIGURE 1.—*A*, A dwarf running bamboo, *Shibataea kumasasa*, showing the horizontal underground stem (rhizome) and roots; *B*, four generations of bamboo rhizomes showing sympodial branching typical of clump bamboo (the fourth generation is represented by a broken stub).

TABLE 1.—*Species and varieties of bamboo established by the Federal Experiment Station at Mayaguez, P. R.*

| Species, variety, and authority | B. P. I.[1] number | Type of growth | Age of oldest plant | Average height attained | Average culm diameter |
|---|---|---|---|---|---|
| | | | *Years* | *Feet* | *Inches* |
| *Arundinaria longiaurita* Hand. Mazz. | 66781 | running | 1 | 2 | 1/8 |
| *Arundinaria amabilis* McClure | 110509 | running | 1 | 2 | 1/8 |
| *Bambusa arundinacea* (of authors) (*Bambusa Bambos* (L.)) Voss. | 21317 | clump | 10 | 65 | 6 |
| *Bambusa longispiculta* Gamble ex Brandis | 93573 | clump | 10 | 38 | 2½ |
| *Bambusa multiplex* (Lour.) Raeusch. var. Alphonse Karr | 73959 | clump | 1 | 3 | ½ |
| var. Fernleaf | 73958 | clump | 4 | 10 | ¾ |
| var. Stripestem Fernleaf | 99289 | clump | 4 | 10 | ½ |
| *Bambusa polymorpha* Munro | 61373 | clump | 10 | 45 | 2¾ |
| *Bambusa textilis* McClure | 80872 | clump | 2 | 29 | 1¼ |
| *Bambusa tulda* Roxb. | 21002 | clump | 20+ | 50 | 3 |
| *Bambusa tuldoides* Munro | 21349 | clump | 10 | 45 | 2¼ |
| *Bambusa ventricosa* McClure | 77013 | clump | 10 | 35 | 1¼ |
| *Bambusa vulgaris* Schrad. ex Wendl. | | clump | 20 | 50 | 3½ |
| *Bambusa vulgaris vittata* A. & C. Riviere | | clump | 9 | 35 | 3 |
| *Bambusa* sp. | 74413 | clump | 10 | 40 | 2¾ |
| *Cephalostachyum pergracile* Munro | 64808 | clump | 10 | 15 | 1¼ |
| *Cephalostachyum* sp. | 126493 | clump | 6 | 15 | 1¼ |
| *Dendrocalamus asper* (Schultes) Backer | 71258 | clump | 3 | 60 | 4 |
| *Dendrocalamus giganteus* Munro | | clump | 2 | 8 | ¾ |
| *Dendrocalamus membranaceus* Munro | 74229 | clump | 8 | 35 | 2¼ |
| *Dendrocalamus strictus* Nees | 77061 | clump | 9 | 40 | 2½ |
| *Gigantochloa apus* (Roem. & Schult.) Kurz ex Munro | 99573 | clump | 7 | 45 | 2¾ |
| *Guadua angustifolia* (H.B.K.) Kunth | 132895 | clump | 6 | 50 | 4½ |
| *Guadua amplexifolia* Presl. | 132894 | clump | 6 | 40 | 2 |
| *Oxytenanthera abyssinica* (A. Rich) Munro | 73863 | clump | 1 | 2 | ½ |
| *Phyllostachys bambusoides* Sieb. & Zucc. | 40842 | running | 10+ | 8 | 1 |
| *Phyllostachys dulcis* McClure | 73452 | running | 1 | 2 | ½ |
| *Phyllostachys meyeri* McClure | | running | 15+ | 9 | ¾ |
| *Shibataea kumasasa* (Steud.) Makino | 101174 | running | 2 | 1 | ⅛ |
| *Sinocalamus oldhami* (Munro) McClure | 76496 | clump | 10 | 48 | 3¼ |

[1] Bureau of Plant Industry, Soils, and Agricultural Engineering.

powder-post beetle, but until such treatments are developed the characteristic of natural resistance is of major importance.

In this publication five species of clump bamboo have been chosen as outstanding in the experience of the station. Several other species also show promise of being equal to or possibly better than these five, but experience with them at the station to date has been limited. The most utilized species established at the station is *Bambusa tulda* Roxb. (fig. 2, *A*) which was introduced about 1903 and is native to India. The culms are fairly straight, green, and smooth with relatively few lateral branches. Under favorable growing conditions culms attain

heights of 60 to 70 feet with basal diameters up to 4 or 5 inches. The culms are strong and thick-walled but can be split easily when desired. Experience at the station has shown that culms of this species are quite resistant to attack by the powder-post beetle when properly cured.

Another species of tested value is *Bambusa longispiculata* Gamble ex Brandis (fig. 2, *B*) which was introduced in 1932 and is also native to India. In appearance it is quite similar to *B. tulda* except that there are usually fewer lateral branches and the green culms are often variegated with white longitudinal stripes. However, this latter feature is not objectionable because upon drying the entire culm becomes yellow. Usually the culm internodes are somewhat longer than


FIGURE 2.—*A*, A large clump of *Bambusa tulda* about 10 years of age. *B*, A clump of *B. longispiculata* 5 years of age, with royal palm in foreground.

those of *B. tulda*. Culms attain heights of 40 to 50 feet with basal diameters of 3 to 4 inches. They are fairly thick-walled but can be split easily when desired. Numerous tiny hairs are found below each node but they shed off in curing and leave pits scarcely visible to the naked eye. Although the cured culms are relatively resistant to the powder-post beetle, frequently beetles have been observed to occur inside the culms without causing outward evidence. Nevertheless, *B. longispiculata* is successfully utilized for many purposes and grows well under Puerto Rican conditions.

*Bambusa textilis* McClure (cover illustration) was introduced in 1935 and is indigenous to China. It is a rather medium-sized clump bamboo which sometimes reaches a height of about 40 feet. The basal

culm diameters rarely exceed 2 inches. The culm walls are thin, usually about 5 millimeters in thickness. Generally, the culms grow very straight in compact clumps. It is an excellent species where a small, straight, thin-walled bamboo is desired. At this station *B. textilis* has shown the greatest resistance to attack by the bamboo powder-post beetle of any species yet studied.

*Bambusa tuldoides* Munro (fig. 3, *A*) was introduced in 1935 and is also indigenous to China. It appears similar in some respects to *B. tulda* but the culms are of more uniform diameter throughout their length and they usually possess a larger number of lateral branches. The foliage does not appear to be so dense as that of the other species nor are the culms as straight. However, they are thick-walled, strong, and are useful in many ways. The culms are the least resistant to the powder-post beetle of the five species discussed here. Nevertheless,


FIGURE 3.—*A*, A clump of *Bambusa tuldoides* 10 years of age. *B*, Clumps of *Sinocalamus oldhami* 10 years of age.

culms of *B. tuldoides* are considerably better in this respect than those of many other species.

*Sinocalamus oldhami* (Munro) McClure (fig. 3, *B*) has not been extensively utilized by the station because few plants were available. However, it has excellent characteristics which warrant recommendation. This species was introduced in 1935 and is native to China. The culms grow to heights of 60 to 70 feet with basal diameters of 3 to 4 inches. They are unusually straight with few lateral branches and have relatively thick walls. For all practical purposes it is almost totally resistant to the bamboo powder-post beetle.

Of the other species of bamboo established at the station several are promising and in time may prove equally or even more important than the five species listed above. Some of these are: *Bambusa polymorpha*, *Dendrocalamus strictus*, *D. giganteus*, *D. membranaceus*, *D. asper*, and *Gigantochloa apus.*

## PROPAGATION

**Divisions.**—The most common method of propagating clump bamboos is by division of the subterranean parts (*7*, *9*). These are prepared by cutting the culm or culms immediately above the second or third node from the base. After preliminary excavation the culm stump which remains is separated from its parent clump with an ax (fig. 4, *A*), The resulting division with a portion of the underground parts will weigh 15 to 30 pounds (fig. 4, *B*) with species which develop large culms. Sometimes is is convenient to include 2 or 3 culm stumps in one division. Often all the culms of a clump are cut simultaneously and the entire clump is then divided.

Soon after planting in the field, dormant buds at the nodes of the culm stumps produce leafy branches (fig. 5). Within a few months several new culms arise from the underground parts. By the end of the third year clumps often develop many culms. For example, individual clumps of *Bambusa textilis* (cover illustration) produced as many as 35 culms during the third year alone. In most species only 6 to 8 culms are produced in this time.

Bamboo divisions are almost certain to live and to grow rapidly if given proper care. However, this method of propagation is costly. In an 8-hour day one laborer usually can prepare only three divisions from a large clump of old bamboo. In addition, division disrupts the development of the clump and may seriously reduce the number of new culms produced. Furthermore, the weight and bulkiness of the divisions create a difficult transportation problem which often limits their distribution.

In comparison with propagation by cuttings, described later, divisions produce relatively few new plants per clump of propagating material. However, until other methods of propagation are perfected, divison will probably continue to be the most important method of propagating clump bamboos. The amount of labor required for preparing divisions of species which develop small culms is, of course, less than for those which develop large culms.

**Layering.**—Many bamboos can be propagated by burying live culms (fig. 6) (*20*, *21*). These should be about 2 or 3 years of age and each culm should be separated as a unit from its parent clump. Some excavation at the base of the culm is necessary in order to include a functional portion of the underground parts. An ax is required to cut through the nearly solid mass of rhizomes and roots in the same way as for preparation of divisions. All primary branches on the culm should be pruned to stumps 1 to 3 feet in length. A few secondary branches (these arise on either side of a larger primary branch) should be left intact with their foliage. The culm then should be placed horizontally in a furrow 6 to 8 inches deep and all parts covered with soil except the leaves of the small secondary branches. Particular care must be taken to pack the soil tightly around the butt end where new shoots will first arise.

After a few weeks new roots and shoots develop at nearly all nodes of the buried culm, if the particular species is adapted to this method of propagation. However, subdivision should not be done until the root system at each node has developed extensively, which may require

772766°—48——2


FIGURE 4.—*A*, Dividing a clump of *Bambusa longispiculata*. *B*, A single division of *B. tulda* ready to plant.

6 to 8 months. At this time the soil should be removed carefully near the center of each internode and the buried culm cut through with a saw causing as little disturbance as possible. The soil should then be replaced and the divided plants allowed to grow without interference for at least 3 months. Following this interval each new plant may be dug and transplanted to a permanent location where it will develop similar to the usual clump division but somewhat more slowly for the first year or two.

FIGURE 5.—A few weeks after planting a division, leafy branches arise from dormant buds at the nodes on the culm stump. The above division is *Dendrocalamus asper*.

FIGURE 6.—A culm of *Dendrocalamus strictus* placed in a furrow prior to covering with soil. The branches are cut back, but a few leaves are exposed. Rooting occurs at the nodes.

**Cuttings.**—Different types of cuttings may be obtained from bamboo culms but there is considerable variation in rooting habits among species. For example, green culm sections of *Bambusa vulgaris* 2 to 4 feet in length often root when planted in moist soil. Culm sections of many other species, however, never show indications of rooting and soon die. A more promising method is the use of cuttings made from the basal parts of branches (*2*, *7*, *27*). Each branch has an en-

larged region at its point of origin on the culm. This enlargement is composed of a series of extremely short internodes separated by nodes which often possess the ability to produce roots; in fact, small root initials develop naturally from these nodes in some species. Branches should be removed as closely as possible to the culm with a hacksaw or similar tool. At the opposite end, the tip of the branch should be cut off about 1 foot from the enlarged base (fig. 7, *a*). The part left will then be a cutting with an enlarged base and 2 to 4 nodes and internodes of ordinary length above the base. This can be planted in a nursery bed and new growth will often start in 4 to 6 weeks. After 6 months to a year the rooted cuttings can be transplanted to the field.

Unfortunately branch cuttings of some species root poorly or not at all. In an experiment in which synthetic root-promoting substances were tested, there was no advantage from indole-3-acetic acid, indole-4-butyric acid, alpha naphthylacetimide, and 2,4-dichlorophenoxyacetic acid used at the usual concentrations.

In some species the rooting of bamboo branch cuttings varies with the time of year they are taken. This was demonstrated with several species of cuttings taken in groups of 50 at 3-month intervals. For uniformity, all cuttings were obtained from 2-year-old culms and were planted in sand in a greenhouse. The results are presented in table 2 as the percentage of cuttings rooted 3 months after planting. Cuttings of *Bambusa polymorpha*, *B. tulda*, and *Dendrocalamus asper* rooted best when taken in December. Cuttings of *Sinocalamus oldhami* rooted best when taken in March, while those of *Gigantochloa apus* rooted equally well in either month. September was apparently a poor month for taking cuttings of any species.

Propagation by cuttings has certain advantages over the use of divisions. Less labor is required for their preparation, a larger number of progeny is obtained per parent clump, and cuttings are less expensive to ship. On the other hand, rooted cuttings require more care the first year or two than plants started from divisions and a higher mortality may be expected.

TABLE 2.—*Rooting of bamboo side-branch cuttings in relation to the time of year they were obtained*

| Species | Rooted cuttings obtained in— | | | |
|---|---|---|---|---|
| | March | June | September | December |
| | *Percent* | *Percent* | *Percent* | *Percent* |
| *Bambusa longispiculata* | 2 | 0 | 0 | 0 |
| *Bambusa polymorpha* | 0 | 0 | 0 | 12 |
| *Bambusa textilis* | 16 | 25 | 2 | 0 |
| *Bambusa tulda* | 2 | 0 | 0 | 12 |
| *Bambusa tuldoides* | 0 | 0 | 0 | 0 |
| *Cephalostachyum pergracile* | 0 | 0 | 0 | 0 |
| *Dendrocalamus asper* | 20 | 0 | 20 | 52 |
| *Gigantochloa apus* | 50 | 46 | 0 | 50 |
| *Sinocalamus oldhami* | 36 | 24 | 8 | 16 |
| Average | 14 | 10 | 3 | 15 |

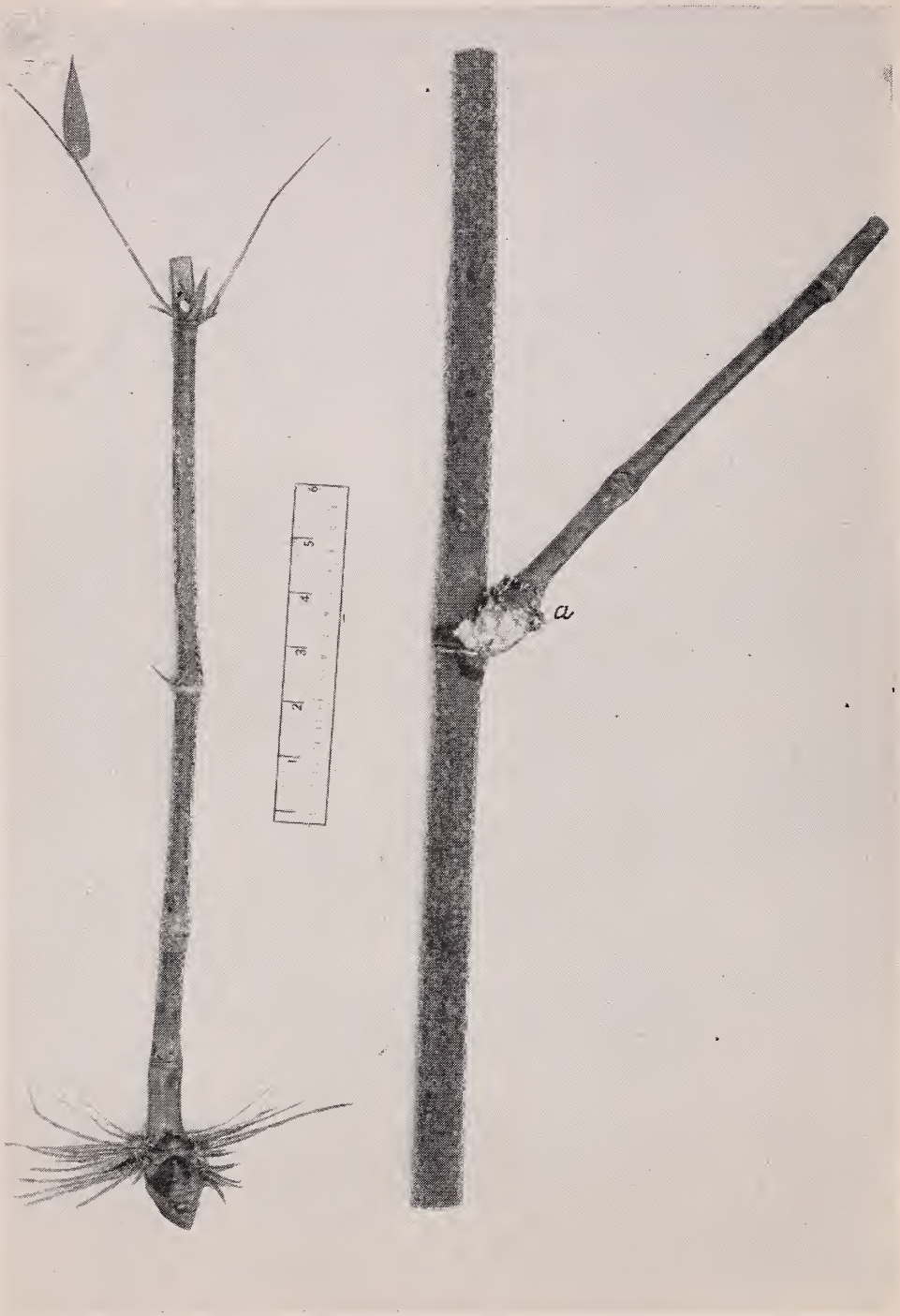


FIGURE 7.—At the right is a culm section of *Dendrocalamus asper* with a branch suitable for use as a cutting. Note the enlarged region at the base of the branch and the small root initials arising from the nodes at "*a*". At the left is a rooted cutting of the same species 2 months after planting.

**Seed.**—The viability of seed of *Bambusa arundinacea* was found to deteriorate after 3 to 4 months unless it was stored under conditions of low humidity (*25*). Without special storage conditions the seed deteriorated and could not be germinated 6 months after harvest. Although storage in a tight jar containing hydrated lime in the bottom increased longevity to some extent, the best treatment was storage over calcium chloride at room temperature. Six months after harvest, seeds stored over calcium chloride had an average of 84 percent germination.

Seed of *Bambusa arundicacea* was sown in soil at a depth of ¼ inch about 1 inch apart in rows 3 or 4 inches apart. Germination occurred in about 1 week and the seedlings grew quite rapidly. When the plants were 6 to 8 inches high they were transplanted to individual containers holding about 1 gallon of soil. Transplanting to the field was done after the plants were 2½ to 3 feet in height (fig. 8). Growing the

FIGURE 8.—These plants of *Bambusa arundinacea* grew from seed collected in February 1945. Seedlings 2 to 3 feet in height were planted 6 feet apart 6 months previously. The rapid growth has already made this planting useful as a windbreak. (Photograph taken October 1946.)

plants from seed is undoubtedly the most economical and convenient method of propagating large numbers of plants. It is unfortunate that flowering and seeding of bamboo cannot be artifically induced for propagation purposes as yet.

**Other propagation methods.**—Several other methods of vegetative propagation have been employed for bamboo with varying degrees of success (*7*, *20*). Marcottage of the nodes, for example, is often successful but is cumbersome. Sometimes the hollow spaces of culm sections have been filled with mud and these large cuttings planted horizontally. Rooting of the nodes follows in some instances. However, none of these methods of propagation result in success comparable to the use of clump divisions or seed.

## PLANTING

**Location.**—The environmental requirements of clump bamboos vary among species, as some are indigenous to the Tropics and others to more temperate climates. Many clump bamboos will grow not only in tropical and subtropical areas but also in the Gulf region of the United States. Young (*31*) reports several species to have withstood temperatures of 15° to 17° F. with little or no injury. On the other hand, sufficient rainfall is a requisite that must be met, since few, if any, species will live in arid regions without irrigation. Usually about 40 inches of rainfall well distributed throughout the year is the minimum.

Bamboo will grow in almost any soil which is not extremely acid or alkaline. Although the plants thrive in fertile soils one outstanding advantage of bamboo is its ability to grow on hillsides which will not support the usual economic crops. In this respect it is excellent for the control of erosion on steep hillsides and riverbanks. Bamboo often makes its greatest growth along the banks of rivers or ponds.

Bamboo is also excellent for landscaping and is superior to most plants for screening purposes or to form a background. Many species, such as *Bambusa polymorpha*, make beautiful specimen clumps when set individually or in small groups in a spacious lawn. However, certain species, such as *Dendrocalamus asper*, shed undesirable amounts of leaves and culm sheaths.

**Planting procedure.**—Planting should be done early in the rainy season if at all possible. In any case, new plants should not be set out unless at least 1 or 2 months of sufficient rain may be expected to maintain moist soil. Planting at the beginning of, or during, a dry season always results in high mortality if irrigation is not practiced.

In preparing land for planting bamboo, it is usually necessary only to clear the area of weeds and brush but not to cultivate. In case the planting is to be made on soil subject to erosion, cultivation may be harmful. The important steps in planting divisions, or other bamboo propagation material, are as follows: (1) Prepare a hole at least 1 foot deep and 1 foot in diameter; (2) place at least 2 inches of well rotted manure or compost in the bottom and cover with a little soil; (3) place the division at the same level in the hole as it previously grew and fill in with soil; (4) tamp the soil firmly around the division (fig. 9); and (5) mound the soil 2 or 3 inches higher than the surrounding ground level. Such holes may seem larger than necessary but their value lies in having loosened soil in the region of new root development.

**Planting distances.**—The most common planting arrangements for bamboo are: (1) Square, (2) hexagon or triangle, and (3) contour. In the first system a clump is established in each corner of a square, whatever the distance may be. Although this system is widely used for tree crops there is no particular advantage for bamboo. A better arrangement is the triangular system in which a clump is located in each corner of an equilateral triangle. By this system, 15 percent more plants are established per acre than by the square system. The contour system may be followed on steep hills for the purpose of reducing erosion.

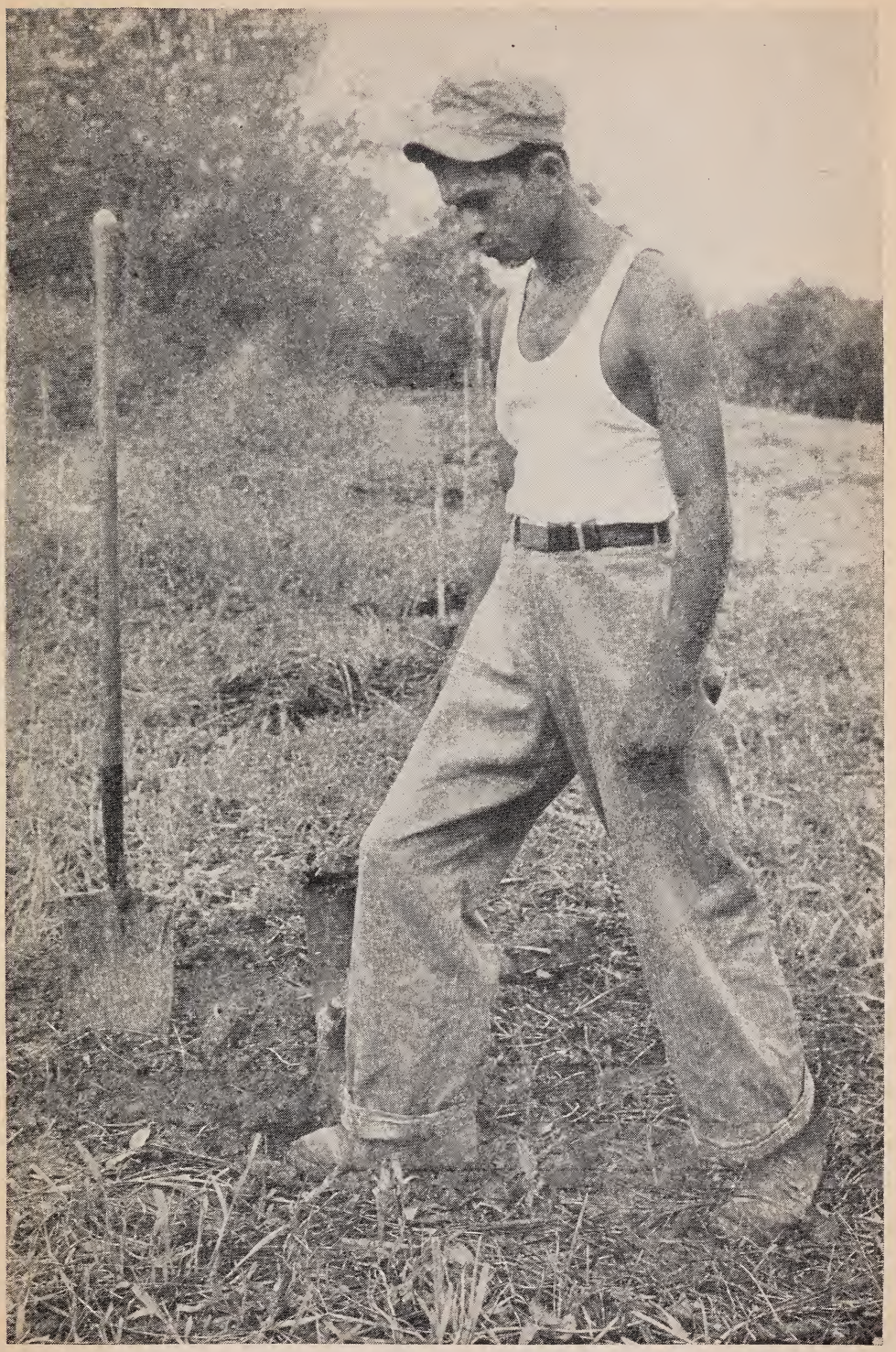

FIGURE 9.—It is important to pack the soil around the underground parts of a transplanted bamboo division.

772766°—48——3

Planting distance for bamboo varies with species and growing conditions. Suggested distances for the triangular planting of five species are presented in table 3.

TABLE 3.—*Suggested planting distances for clump bamboos set by the triangular system*

| Species | On poor soil or in an unfavorable climate | | On good soil and in a favorable climate | |
|---|---|---|---|---|
| | Distance | Plants per acre | Distance | Plants per acre |
| | *Feet* | *Number* | *Feet* | *Number* |
| *Bambusa longispiculata* | 15 | 223 | 25 | 80 |
| *Bambusa textilis* | 12 | 348 | 20 | 125 |
| *Bambusa tulda* | 18 | 158 | 25 | 80 |
| *Bambusa tuldoides* | 15 | 223 | 25 | 80 |
| *Sinocalamus oldhami* | 18 | 158 | 25 | 80 |

## MAINTENANCE

**Watering, mulching, and weeding.**—It is important that new plants receive water within a few days. Even later, after new shoots have arisen from the nodes on newly planted culm stumps, it is advisable to apply 3 to 5 gallons of water to each plant in unusually dry weather. A practical method to conserve soil moisture is to apply a leafy mulch (*26*). Generally a good mulch applied toward the end of the rainy season will help maintain adequate soil moisture for many weeks (fig. 10, *A*). The mulch may consist of almost any type of organic matter, although bamboo leaves and grasses are most frequently used. In order for a mulch to be effective, it must be applied about 1 foot deep around the base of the plant. Mulching may be practiced to advantage for at least 2 years after planting.

It is not necessary to weed or cultivate bamboo as is done for most other crops. When weeds become a foot or more in height they should be mowed. After 3 or 4 years the bamboo usually will have made sufficient growth to "shade out" weeds and mowing will no longer be required.

**Cover crops.**—A promising practice is to establish a cover crop among newly set bamboo plants. A cover crop should be leguminous so that nitrogen shall not be depleted from the soil. In addition a cover crop from bamboo should be easily established and be preferably a vigorous perennial which does not lose its leaves during the dry season and become a fire hazard.

The best cover crop tested under Puerto Rican conditions thus far has been tropical kudzu, *Pueraria phaseoloides* (Roxb.) Benth. (*23*, *24*). A few seeds of this plant may be scattered on prepared areas about 3 feet in diameter among new bamboo plants (fig. 10, *B*.) With little care the tropical kudzu should develop vigorous vines that will cover the field within a year to 18 months. The plants remain green indefinitely and will smother almost all weeds and grasses. Care must be taken to keep the vines from climbing the bamboo in the first few


FIGURE 10.—*A*, A field of newly planted bamboo divisions mulched with bamboo leaves to help conserve soil moisture. *B*, Areas of *Pueraria phaseoloides* established as a cover crop between young bamboo plants; the vines later covered the entire area, smothering weeds and grasses.

years. This type of cover crop not only helps to "build up" the soil but also aids in preventing erosion which may occur in the first 2 or 3 years while the bamboo is developing an extensive root system. The maintenance costs of bamboo planted with an established cover crop would be less than the cost of periodic mowing of weeds. When the bamboo is 4 to 5 years old it will begin to shade out the cover crop.

**Fertilization.**—No literature has come to the attention of the writer concerning the response of clump bamboos to fertilization. However, from recent preliminary data obtained in an experiment at this station there are indications that fertilization would be advantageous on soils of low fertility. In this experiment applications of 3 pounds of complete fertilizer (12–10–6) per plant 1 and 2 years after planting divisions of 5 species resulted in a larger average number of shoots per clump and a larger percentage of fully developed culms 6 months after the second application. There were no noticeable differences in culm diameters or heights between fertilized clumps and those not fertilized.

In many instances the supply of available soil nutrients may not be a limiting factor. Therefore, each planting of bamboo presents an individual problem insofar as fertilization is concerned. It is recommended that a few clumps be fertilized experimentally in order to determine whether the response is economically sound.

## DEVELOPMENT OF CLUMPS

**Flowering and fruiting.**—The bamboos are perennial grasses in which flowering generally occurs only at intervals of many years. Records in India indicate that from about 20 to 80 years or more are required to complete the life cycle, as measured from one flowering date to the next. The long-time intervals between blooms have limited specific knowledge of the flowering habits of many bamboo species. Plants of a single species usually flower gregariously, i. e., all the plants of the species produce flowers about the same time regardless of the age of the clump or culms within a clump. However, there are often variations within a species. For example, at the station some culms of *Bambusa arundinacea* (of authors) (*Bambusa Bambos* (L.) Voss) (a spiny species) flowered in 1945 and others in 1946 (fig. 11), but there were still some virgin culms which had not flowered.

The flowers of *Bambusa arundinacea* are roughly typical of those of all bamboos. They are borne in spikelets which arise from nodes as shown in figure 12. The fruit is a caryopsis which is similar in form and size to the common oat. The flowering and fruiting of bamboo affect the vegetative development of the plant to a variable extent. If few flowers and fruits occur there is no noticeable change in growth. Thus, in 1944 and 1945 a few flowers and fruits were produced on several culms of *Guadua angustifolia* (H. B. K.) Kunth but vegetative development of the clumps did not appear to have been affected. On the other hand, the profuse flowering and fruiting of other clumps of *B. arundinacea* in most instances was followed by death of all aboveground portions and usually the underground parts also.

The factor or factors responsible for the flowering of a bamboo plant after an indefinite period of vegetative development are not known but apparently they are specific for a species. For example, although only two species have flowered simultaneously at the station, 27 other

FIGURE 11.—Flowering culms of *Bambusa arundinacea*, a spiny bamboo. The leaves have all been shed and the culms are dying. In the lower center background may be seen foliage of another clump of the same species which is not in flower.

species have been subject to the same environment. The flowering factor is also apparently well distributed throughout the plant and is not associated with the age of the culms. This was evidenced recently by a clump of *Bambusa arundinacea*, several culms of which produced a few flowers and the others no flowers. Later in the year all the culms were cut and several months afterward shoots 4 to 6 feet in length developed from the bases of the culm stumps. These shoots soon flowered profusely and then died, indicating that the factor for

FIGURE 12.—Flowering branches of *Bambusa arundinacea* are shown at the right. A few mature seeds are shown at the lower left and a seeding about 3 weeks old at the upper left.

flowering had been present in the culm stumps and perhaps in the underground parts as well.

The possibility of artificially inducing flowering in bamboo is of great interest. Taxonomists, for example, are confronted with considerable difficulty in identifying the various species because of the long intervals between flowering. From a practical standpoint, the distribution of select bamboo species would be facilitated if it could be accomplished by means of seed rather than divisions. Certainly the propagation of large numbers of plants can be done much more economically by seed, when available, than by any other method.

**Rate of growth.**—The rate of growth of bamboo is dependent on many factors and one of the more decisive is the inherent tendencies of the species. Some species of clump bamboo become only a few feet high when mature, such as certain varities of *Bambusa multiplex*, and many others attain heights of 80 feet or more. Culm diameters are usually proportionate to the height, ranging from less than an inch to 8 inches or more. Aside from the inherent ability of the species to grow tall or short, there is also considerable difference in the number of shoots which develop in a clump. For example, clumps of *Dendrocalamus asper* were observed to develop only 3 or 4 culms per clump the second year after planting while those of *B. textilis* developed 30 to 37 culms in the same period on similar soil. These are extreme examples and usually about 5 to 10 new culms are produced by each clump each year under favorable conditions.

The ability to continue production of culms after the clumps become larger is dependent upon such factors as soil fertility, moisture, and distance of planting. Usually, clumps of *Bambusa tulda*, *B. tuldoides*, and *B. longispiculata* will develop 30 to 40 culms within 4 to 6 years after planting. After 10 to 12 years the oldest culms die at about the same rate as new culms are produced and the clump is said to be mature. In some species the foliage becomes light green or partially yellow in color during dry weather. Total leaf abscission is not common and most bamboos produce new leaves at about the same rate older leaves abscise.

The new culms which arise toward the end of the rainy season each year are larger in diameter and attain greater height than those of the previous year until maturity is reached (fig. 13). Some of the shoots which arise each year may die and this appears to be characteristic for the species. Whereas almost 100 percent of the shoots of *Bambusa textilis* were observed to develop into culms, about 50 percent of the shoots of *Dendrocalamus asper* died soon after emergence. This has been thought to be due possibly to the initiation of more new shoots than could develop from the available food materials. To date no evidence of a specific disease that might cause the death of the shoots has been found. The new culms almost always arise outside the culms of the previous year and, therefore, in a mature clump the youngest and largest culms form a more or less concentric ring around older culms arranged in similar rings.

Culm growth may be completed in a matter of 2 or 3 months or less. In many cases the elongation of a culm is extremely rapid. For example, Arber (*1*) reports that a culm of *Bambusa arundinacea* grew 91 centimeters (almost a yard) within 24 hours. Once the culm has attained its full height no more growth occurs and, under favorable conditions, it may live for 10 or more years.

**Root system.**—The soil around bamboo plants is permeated by a mass of intertwining roots. A study (*28*) was made to ascertain the typical distribution of roots from an 8-year-old clump of *Bambusa tulda*. Starting at the base of an outermost culm, a ditch was dug to a depth of 4 feet for a distance of 17 feet from the clump (fig. 14). The number of roots exposed in each square foot on the face on one wall of the ditch was recorded. It was found that 83 percent of the roots were present in the upper foot of soil and that few roots penetrated


FIGURE 13.—A 4-year-old clump of *Dendrocalamus asper* in which the small center culms developed the first year after planting. Each year thereafter new culms arose outside the previous year's culms and were of larger size.

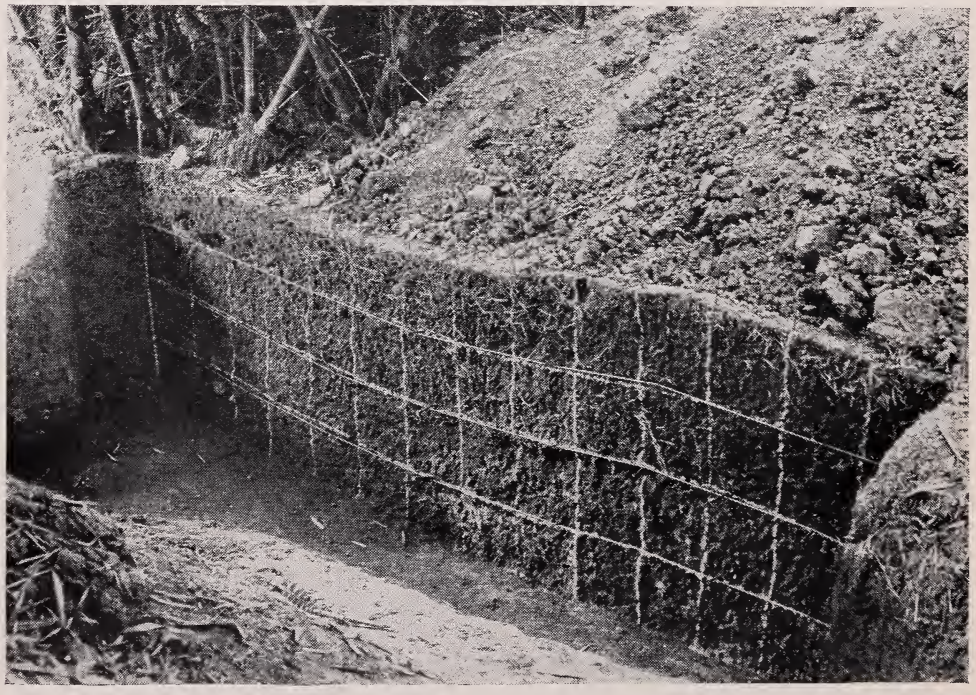

FIGURE 14.—Vertical exposure adjacent to an 8-year-old clump of *Bambusa tulda*. Although somewhat indistinct in this illustration, most of the roots of bamboo are located in the upper foot of soil. The lines are 1 foot apart.

deeper than 4 feet. Some roots extended horizontally 17 feet into a roadway where the observation ditch could not be continued.

Such an extensive fibrous root system is quite effective in arresting soil erosion, but farmers contend that other crops cannot follow bamboo without being adversely affected by decomposition of the bamboo roots. This problem, however, might be caused by depletion of nutrients from the soil by bamboo.

A typical example of the ability of bamboo to control soil erosion was demonstrated in a 4-year planting of *Bambusa longispiculata* located on a 52-percent slope (fig. 15). In addition to the mat of roots which developed between the clumps, there was also an accumulation of 2 to 4 inches of bamboo leaves on the soil surface. This mulch helped to retard the rate of water runoff and thereby reduced erosion and facilitated the infiltration of water. Few other economic crops can be grown with equal success on such steep locations. In Puerto Rico the occurrence of landslides may be prevented by establishing bamboo above and below hillside roads or steep road embankments. The extensive fibrous root system of bamboo also accounts for its effectiveness in preventing the gradual sloughing away of soft riverbanks.

## HARVESTING AND CURING

**Methods of harvest.**—The harvesting of culms of the clump bamboos is a comparatively simple operation requiring two men; one man supports the culm that is to be harvested while the other man cuts it with a machete or saw. It is advisable to use some type of pruning saw for the operation in order to make a clean cut. If the culm stump is to be used for propagation the culm should be cut above the second or third node from the ground. Harvesting is best done during dry weather in order to avoid staining of the cut culms which frequently occurs in rainy weather. Furthermore, curing of cut culms as discussed later is best done in dry weather. The culm stump can remain undisturbed until the rainy season, at which time they may be dug for replanting.

**Systems of harvest.**—Unfortunately, there seems to be no exact information as to the effect of harvesting on development of new culms of clump bamboos. In the Orient, clump bamboos are sometimes partially harvested each year for many years but no definite plan of harvest appears to be followed. Harvesting should not be started until the clumps are well established, about 4 to 5 years after planting at the earliest. If all the culms in a clump are harvested at the same time new culms will arise but these will be of small size. Therefore, complete harvest of all culms in a clump at one time does not seem advisable.

Three other systems for harvesting can be employed according to: (1) Age of culms, (2) diameter of culms, and (3) loction of culms. If harvesting is done according to the age of culms, as for example, if 3-year-old culms are cut each year, then the operation is difficult because such culms are always surrounded by the outer, younger culms. If the species is one having many intertwining side branches, removal of cut culms is not easy and sometimes impossible with this system. On the other hand, culms only 1 or 2 years of age are immature and their

FIGURE 15.—During dry periods bamboo sheds many leaves which have accumulated to form a 2- to 4-inch mulch in this 4-year-old planting of *Bambusa longispiculata*. The fibrous root system and mulch on this 52-percent slope prevented soil erosion.

quality is poor. Therefore, harvesting according to age does not appear feasible in most instances.

If the diameter of the culms is used as a basis for harvesting, difficulties similar to those previously mentioned will be encountered. The most logical system of harvesting appears to be based upon the location of the culms. Since the culms in a clump arise more or less in a circle, each year a "pie" sector of the culms within the circle may be harvested. Under favorable growing conditions possibly one-fourth, more or less, of the culms in each clump may be harvested each year without unduly reducing the production of new culms. Needless to say, the vigor of the species, fertility of the soil, and quantity of culms removed each year will affect the production and size of the new culms. Only experience can indicate the most satisfactory basis for continual harvesting of each species under local conditions. In all cases culms 1 and 2 years of age that may have been harvested should be segregated from the older culms for separate sale.

**Curing.**—The successful utilization of any bamboo depends largely on the durability and other desirable qualities that result with changes in the wood after harvest, commonly called the curing period. Curing may affect appearance or attractiveness by changing color, and durability by decreasing the tendency of the culms to split or to become infested with the bamboo powder-post beetle, *Dinoderus minutus* (F.). The most practical method of curing in the experience of the station (*29*) is to stand the freshly cut culms upright in the field against the clump with all lateral branches and leaves attached for about 4 weeks (fig. 16). During this period the culms dry and turn yellow. Resistance to the powder-post beetle, as discussed later, is also increased if the clumps are properly clump-cured. If they are not cured but are stored at once in sheds, the culms do not attain a desirable even color, they split easily, and they are less resistant to the powder-post beetle. Curing under water (*29*), as often done in the Orient, may increase resistance to the powder-post beetle under Puerto Rican conditions but results in considerable staining and splitting.

**Trimming.**—After the culms have been cured in the field the branches should be removed with a hacksaw and pruning shears. Utilization of the branches is often possible and they should not be destroyed. Each branch should be sawed or clipped as closely to the culm as possible. Workers should be taught to handle each culm so as not to scratch it with tools or other culms, particularly if the culms are to be sold as high-quality material. Considerable damage to excellent culms often results from trimming operations performed by improperly supervised labor. The last operation performed in the field is to cut each culm into sections of whatever lengths are desired. Less waste and expense in transportation will occur if the culms are cut into the proper lengths in the field rather than re-cut later in the storage shed.

**Storage and packing.**—Cured culm sections should be stored horizontally on racks beneath a protective roof (fig. 17). If culms are left in the field longer than is necessary for curing, their quality is lowered by weathering. Culm sections of each species should be kept separate and the sections should be segregated into diameter groups, such as those having basal diameters from ½ to 1, 1 to 1½, and

FIGURE 16.—Freshly cut culms of *Bambusa tuldoides* leaned upright against another clump for curing. The leaves are left attached in order to hasten drying of the culms.

1½ to 2 inches. The large diameter sections are most conveniently handled on bottom racks, while those of small diameter may be stored higher.

The packing of quality culm sections involves special care to avoid scratching. For this purpose the culm sections should be tied tightly in bundles about 1 foot in diameter. Each bundle should then be wrapped in heavy paper and the ends covered with gunny cloth or similar material. In case rough transportation facilities are anticipated the ends of each bundle should be reinforced by a double loop of 16–gauge wire outside the gunny cloth.

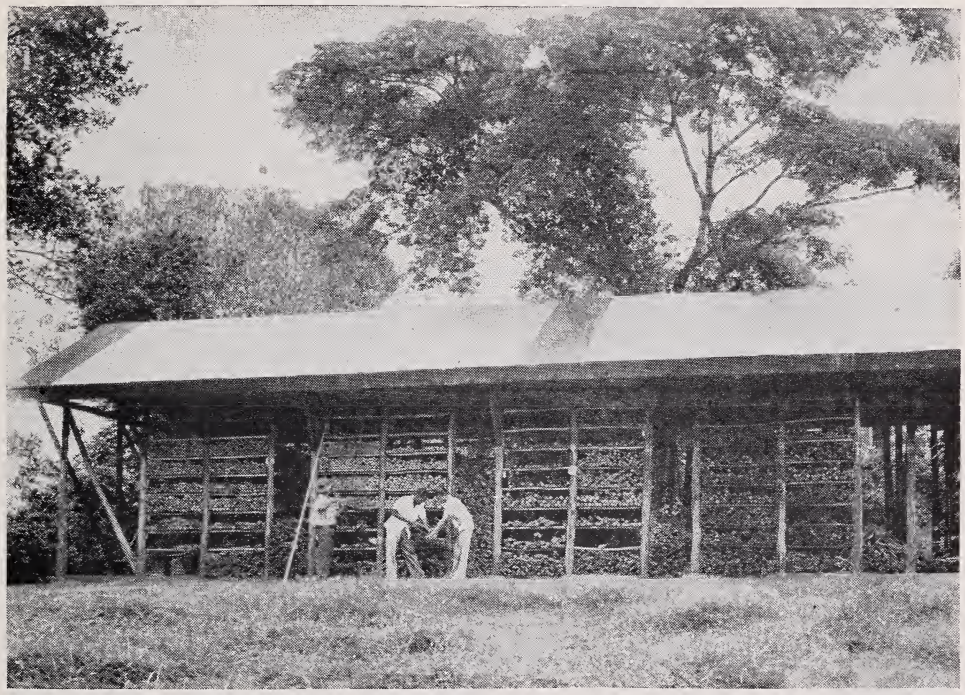

FIGURE 17.—Cured sections of bamboo culms stored horizontally on racks under an open shed. The sections are separated according to their species and their basal diameters.

## INSECTS AND DISEASES

The most important pest of bamboo is the bamboo powder-post beetle (*Dinoderus minutus*), belonging to the family Bostrychidae. The mature beetle is about 3 millimeters in length (fig. 18, *A*) and rarely, if ever, attacks living bamboo. Relatively few beetles are present in the field but a high population may be found under storage conditions. Beetles enter susceptible culms by boring holes about 1 millimeter in diameter, and the larvae eat tunnels throughout the interior parts (fig. 18, *B*) (*16*). Severe infestations weaken and mar the culms to such an extent that they are of no value. If bamboo is to be used for making furniture or similar high-quality items, the culms must be free of damage from powder-post beetles.

An extensive study of the beetle has been made by Plank (*18*) at this station. He found that species vary widely in susceptibility to attack,

as listed earlier, and also that resistance within a species is associated with the age of the culm. In general, older culms are more resistant than younger culms and the distal ends of culms are more resistant than basal parts. There are many indications that the beetles prefer culms or parts of culms high in starch and that culms low in starch are relatively resistant (*16*). For reasons not well understood culms

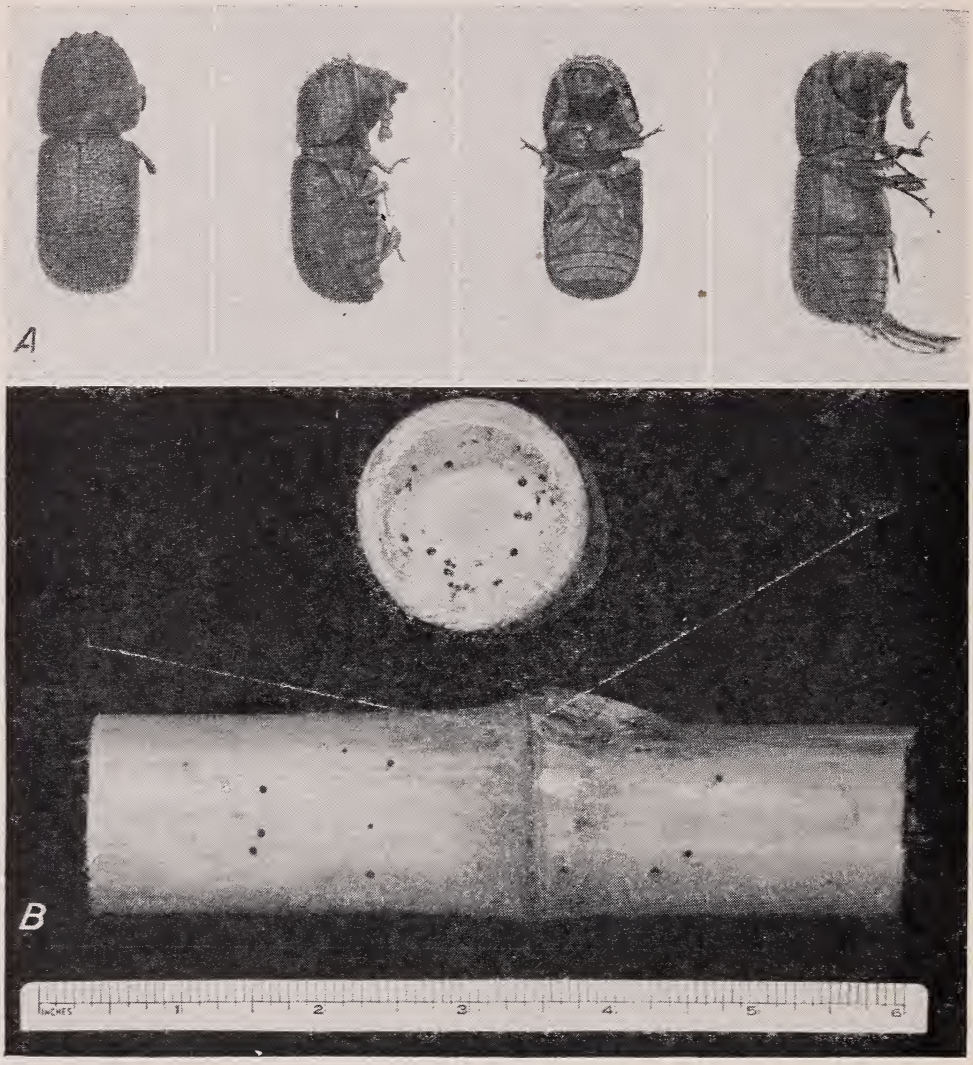


FIGURE 18.—*A*, Adult specimens of the bamboo powder-post beetle (*Dinoderus minutus*) enlarged almost 10×. *B*, Pieces of *Bambusa vulgaris* riddled by the bamboo powder-post beetle.

that do not become infested within a month or two after exposure to the powder-post beetle usually are not attacked later. In fact, the number of beetle holes which appear after an exposure of a few months is more or less indicative of the future total infestation. A severe infestation generally extends over a period of several months and after that the population of beetles tends to decrease.

Many treatments have been tried experimentally to prevent infestation of harvested bamboo by the powder-post beetle. These have in-

cluded the introduction of various chemicals into the wood as well as exterior applications (*15*). In all cases, infestation is reduced if the freshly cut culms are clump-cured as described earlier. Recent experiments have indicated that exterior applications of DDT may be successful in preventing beetle infestation, although additional study is required before such treatments can be recommended (*17*). Also, a recent experiment at this station indicates that if clump-cured bamboo is immediately stored in an environment protected from beetles for a few months, no subsequent infestation occurs. However, neither of these treatments can be recommended until more data are available.

In some cases a few specimens of the beetles *Lyctus caribeanus* Lesne and *L. curtulis* Casey have been found to infest cut culms but their damage is relatively unimportant (*15*). Cut culms are also susceptible to attack by the dry wood "powder-post" termite, *Kalotermes* (*Cryptotermes*) *brevis* Walker and the common ground termite, *Nasutitermes* (*Nasutitermes*) *costalis* Holmgren. Bamboo culms are neither unusually susceptible nor particularly resistant to these latter two insects.

Live culms and foliage of bamboo are susceptible to infestation by scale insects, particularly *Asterolecanium bambusae* Bvd. and *A. miliaris* Bvd. (*14*). Scales mar the culms and interfere with proper development of bamboo. Fortunately these scales are no longer a problem for bamboo grown in Puerto Rico because of insect predators introduced by the station (*22*). The most effective predator on bamboo scales is a ladybeetle, *Egius platycephalus* Muls., which is able to maintain itself under conditions of extremely light scale infestation. A number of other species, particularly *Chilocorus cacti* L., *Cladis nitidula* (F.), and *Pentilia castanea* Muls. are prevalent and commonly found feeding on different scales.

In Puerto Rico there are no other important insects attacking bamboo and fortunately there are at present no important bamboo diseases.

## UTILIZATION OF BAMBOO

**General.**—Bamboo is one of the most widely used plants in the world. Probably few persons in North America realize that this giant member of the grass family is an irreplaceable basic material for millions of people in the Orient as well as in South and Central Americas (*10*, *12*). Throughout the milder parts of Asia and the adjacent islands, from China and Japan to India and the East Indies, bamboo is used for many purposes, including the use of the young shoots for food. In addition to local uses, considerable quantities of canned bamboo shoots and of cured culms are exported from the Orient to North America.

**Young shoots for food.**—The young shoots of many medium- and large-sized bamboos, including several of the clump type, are reported to be edible. Shoots should be cut soon after they appear, when only a few inches in height, because the basal portion becomes fibrous quickly. However, in some species and under certain conditions, shoots of large diameter may reach a height of a foot without being too fibrous. Each shoot is tightly encased in tough sheaths that must be removed before cooking.

The growing tip of a shoot is quite tender, although fairly firm and crisp. Toward the base it is firmer and may be somewhat fibrous. The more tender parts may be cut into pieces of any desired size and shape, but lower parts that are noticeably fibrous should be cut into thin cross sections to avoid long fibers. In some bamboos, such as the giant thorny bamboo of India, *Bambusa arundinacea*, the shoots are reported to be somewhat bitter to the taste but this can be remedied by changing the water once or twice in cooking. The shoots should be boiled for about 25 minutes. There is seldom any pronounced flavor in bamboo shoots although it has been suggested that their flavor often slightly resembles very young field corn. The shoots do not lose their crispness in cooking. They are commonly used in meat stews and in mixed salads but may also be served in other ways.

**Furniture.**—Until recently only a small part of the bamboo culms imported into the United States was used for the manufacture of furniture. At present, however, there is considerable interest in bamboo for the manufacture of furniture which is light in weight, durable, and particularly adaptable for the Tropics or for summer use elsewhere (*30*). In cooperation with this station, the Puerto Rico Development Co., using designs by Allan Gould,[4] has fostered the manufacture of bamboo chairs, settees, footstools, and similar items (fig. 19). These are made with a bamboo framework that supports seats, backs, and sides woven with leaves of the royal palm. Other attractive weaving materials could be chosen from local products.

The tensile strength of culms of several species of bamboo is phenomenal and almost comparable with steel (*8*). This capacity is due to its cylindrical shape reinforced by the septum of each node, a geometric design near perfection in strength. One difficulty in utilizing bamboo for construction purposes is its inability to take nails or screws without cracking. However, nails or screws may be inserted in holes previously drilled and doweled joints may be glued. Skill and patience are requisites for building articles from bamboo but good craftsmanship is repaid by the natural beauty of the finished product. With experience, manufacturers will undoubtedly develop new and better methods in bamboo construction work.

**Laminated rods and poles.**—Specialized uses of bamboo culms include the manufacture of fishing rods, golf clubs, ski poles, and similar items that require a strong, light-weight wood with resilience. The manufacture of these items is complicated and requires special machinery and experience (fig. 20). Prior to World War II the most important bamboo for these uses was Tonkin cane (*Arundinaria amabilis*) imported from southern China. In the past few years bamboos growing in the Western Hemisphere have been tested for these special uses. In some cases certain species, such as *Bambusa tulda*, have been found to yield culms from which very satisfactory split rods can be made. There are indications that culm strength and quality are affected by rainfall, type of soil, and other environmental factors, as well as by time of harvest and method of curing.

**Farm uses.**—Farmers can use bamboo culms advantageously for many purposes. For example, livestock shelters made with a bamboo

[4] Formerly designer for the company, now designing in New York.

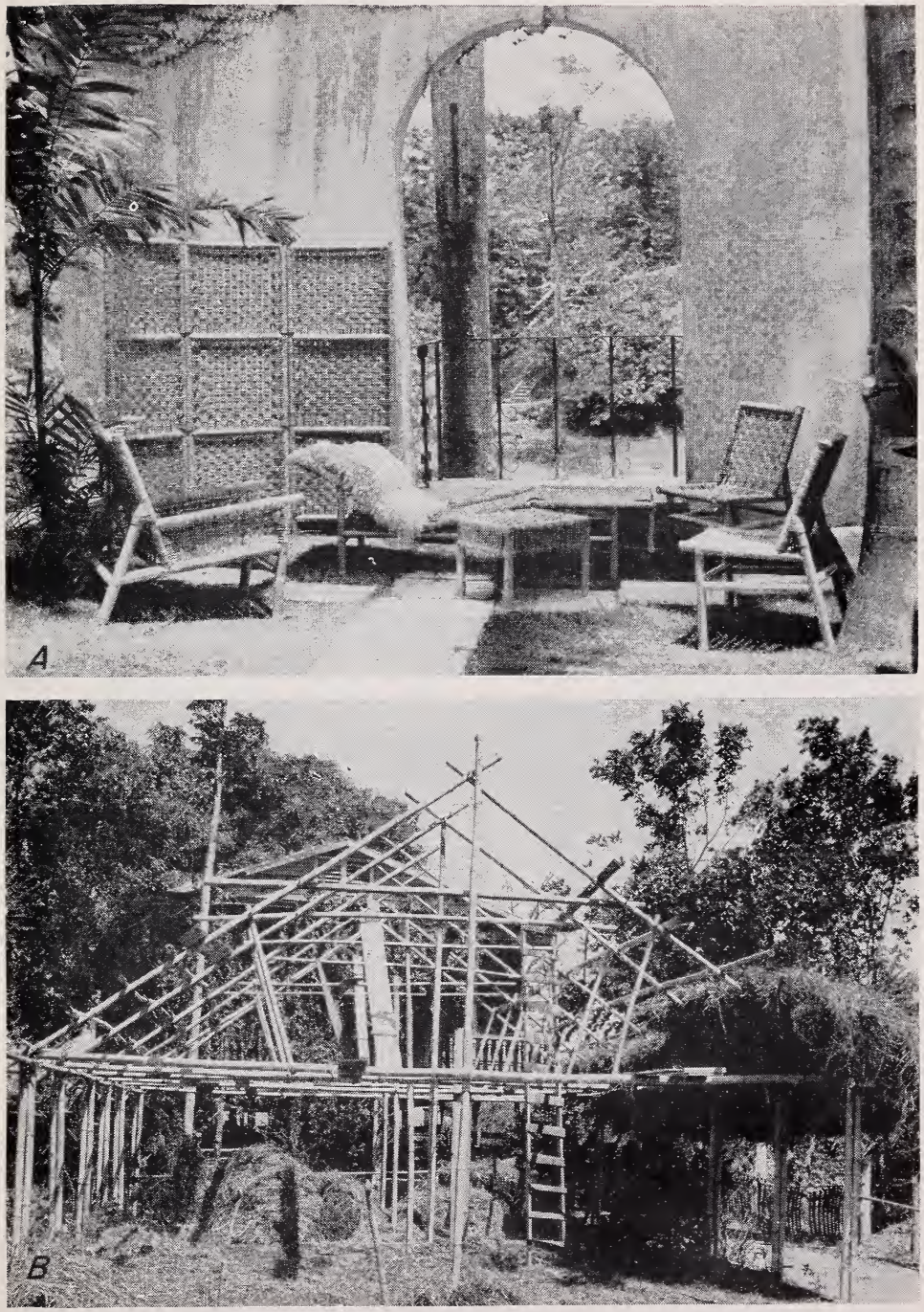


FIGURE 19.—*A*, Bamboo furniture with royal palm leaves twisted and woven for seats and backs. *B*, A shelter suitable for livestock or other purposes constructed with bamboo.

framework and covered with thatch are economical and durable if constructed with culms resistant to the powder-post beetle (fig. 19). The roof may be made from culms split in halves lengthwise and laid like tile rather than using thatch or other roofing material. Commendable houses also can be constructed by using whole culms for the frame and split bamboo for the walls and floors.


FIGURE 20.—The manufacture of split bamboo fishing rods requires special machines. (*A*) Sanding culm nodes; (*B*) sawing strips; (*C*) planing a strip to a triangular shape, (*D*) tying glued sections, (*E*) tying "eyes" on rod, and (*F*) finished rods. (Courtesy of Harry M. Keller, Wendt & Campbell, Inc., Mayaguez, Puerto Rico.)

Culms can be made into fences or used for fence posts. Numerous other farm articles from bamboo are possible, such as tobacco-drying racks, peanut racks, garden stakes, ladders, and tool handles. Bamboo revetments can be constructed along river banks subject to extreme erosion (*3*).

**Miscellaneous uses.**—In spite of their unusual strength, bamboo culms 1 inch or less in diameter can be bent easily and permanently by the application of heat in the form of steam or from a blowtorch. Bending is accomplished by clamping a straight culm piece tangent to the rim of a wheel of desired curvature and placing both in a vise.

As one man applies the heat, another man bends the bamboo steadily over the wheel rim. Graceful curves in many articles are thus possible.

Bamboo is frequently utilized in the decoration of store windows and hotel lounges. Often it is used for paneling in such places and the panels are made most easily from culms split in halves lengthwise. Each half can be attached to a backboard by glueing or by drilling small holes in the bamboo which will accommodate finishing nails. In Puerto Rico one enterprising family has developed a remunerative business manufacturing ladies' handbags decorated with small pieces of bamboo branches about the diameter of a pencil.

Laminated bamboo (squared strips glued together) is even stronger than whole culms and offers possibilities for structures requiring wood of great strength. Bamboo may be impregnated with various plastics which give durability and beauty. In Trinidad and in the Orient bamboo culms have proved useful as a source of paper pulp and this use is under investigation in the continental United States.

There is a multitude of other uses for bamboo. Sportsmen use culms sections for outriggers on motorboats while small sailing craft can use bamboo masts and booms. In addition to use for greenhouse stakes by commercial flower and vegetable growers, bamboo can be made into unique and beautiful porch lattices, flower vases, ash stands and trays, cigarette holders, picture frames, clothes hangers, tweezers, salad tools, spoons, ladles, and numerous knicknacks.

## LITERATURE CITED

(1) Arber, A.
1934. the gramineae: a study of cereal, bamboo, and grass. 480 pp., illus. Cambridge, Eng. (See p. 62.)

(2) Cobin, M.
1945. bamboo production and industrialization. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1944: 29–33. (See pp. 30–31.)

(3) Horn, C. L., and Arroyo, A.
1943. new bamboo revetment construction. Mil. Engin. 35 (212): 284–286, illus.

(4) McClure, F. A.
1931. studies of chinese bamboos: I. a new species of arundinaria from southern china, part 1. diagnosis. Lingnan Sci. Jour. 10: 5–10, illus.

(5) ———
1931. studies of chinese bamboos: I. a new species of arundinaria from southern china. part 2. notes on culture, preparation for market, and uses. Lingnan Sci. Jour. 10: 295–305, illus.

(6) ———
1935. bamboo—a taxonomic problem and an economic opportunity. Sci. Monthly 41: 193–204, illus.

(7) ———
1938. notes on bamboo culture, with special reference to southern china. Hong Kong Nat. IX: 4–18, illus.

(8) ———
1938. some preliminary tests on the longitudinal crushing strength of hua-mei chu, a variety of bambusa tuldoides. Lingnan Sci. Jour. 17: 9–19, illus.

(9) ———
1945. bamboo culture in the americas. Agr. in Americas 5: 3–7, 15–16, illus.

(10) ———
1945. bamboo in ecuador's lowlands. Agr. in Americas 5: 190–192, 194, illus.

(11) ———
1945. THE VEGETATIVE CHARACTERS OF THE BAMBOO GENUS PHYLLOSTACHYS AND DESCRIPTIONS OF EIGHT NEW SPECIES INTRODUCED FROM CHINA. Wash. Acad. Sci. Jour. 35 (9) : 276–293, illus.
(12) ———
1946. BAMBOO IN ECUADOR'S HIGHLANDS. Agr. in Americas 6: 164–167, illus.
(13) ———
1946. THE GENUS BAMBUSA AND SOME OF ITS FIRST-KNOWN SPECIES. Blumea, Sup. III: 90–112, illus.
(14) PLANK, H. K.
1938. BAMBOO PROPAGATION AND UTILIZATION. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1937: 26–37, illus. (See p. 36.)
(15) ———
1939. ENTOMOLOGICAL INVESTIGATIONS. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1938: 109–118, illus.
(16) ———
[1942.] ENTOMOLOGICAL INVESTIGATIONS. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1940: 71–85, illus.
(17) ———
1947. DDT FOR POWDER-POST BEETLE CONTROL IN BAMBOO. Science 106 (2753) : 317.
(18) ———
1948. BIOLOGY OF THE BAMBOO POWDER-POST BEETLE IN PUERTO RICO. Puerto Rico (Mayaguez) Fed. Expt. Sta. Bul. 44:—pp., illus. [In press.]
(19) PUERTO RICO (MAYAGUEZ) AGRICULTURAL EXPERIMENT STATION.
1936. BAMBOO PROPAGATION AND UTILIZATION. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1935 : 16–19, illus.
(20) ———
1937. BAMBOO INTRODUCTION, PROPAGATION, AND UTILIZATION. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1936: 27–39, illus. (See pp. 28–29).
(21) ———
1939. BAMBOO PROPAGATION AND UTILIZATION. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1938: 50–55, illus. (See pp. 50–51.)
(22) ———
1939. PARASITES AND PREDATORS OF SCALE INSECTS. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1938 : 100–107, illus.
(23) TELFORD, E. A., and CHILDERS, N. F.
1945. TROPICAL KUDZU. Agr. in Americas 5 : 210–211, illus.
(24) ——— and CHILDERS, N. F.
1947. TROPICAL KUDZU IN PUERTO RICO. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 27, 29 pp., illus.
(25) WHITE, D. G.
1947. LONGEVITY OF BAMBOO SEED UNDER DIFFERENT STORAGE CONDITIONS. Jour. Trop. Agr. [Trinidad] 24 (4–6) : 51–53, illus.
(26) ———
1947. MULCHING TROPICAL PLANTS. Agr. in Americas 7 : 143–145, illus.
(27) ———
1947. PROPAGATION OF BAMBOO BY BRANCH CUTTINGS. Amer. Soc. Hort. Sci. Proc. 50 : 392–394, illus.
(28) ——— and CHILDERS, N. F.
1945. BAMBOO FOR CONTROLLING SOIL EROSION. Amer. Soc. Agron. Jour. 37 : 839–847, illus.
(29) ———, COBIN, M., and SEGUINOT ROBLES, P.
1946. THE RELATION BETWEEN CURING AND DURABILITY OF BAMBUSA TULDOIDES. U. S. Forest Serv., Caribbean Forester 7 : 253–273, illus.
(30) ——— and HUYKE, J. B.
1946. EL BAMBÚ, UN PRODUCTO DE UTILIDAD PARA LA FINCA Y PARA EL HOGAR. Rev. de Agr. de Puerto Rico 37 : 18–22, illus.
(31) YOUNG, R. A.
1946. BMBOOS IN AMERICAN HORTICULTURE (IV). Nat. Hort. Mag. 25: 257–283.

U. S. GOVERNMENT PRINTING OFFICE: 1948

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 10 cents