

# **BAMBOO SPECIES INTRODUCED IN ETHIOPIA**

***Biological, Ecological and Management Aspects***



**Yigardu Mulatu  
Asabeneh Alemayehu  
Zebene Tadesse**



**Ethiopian Environment and Forest Research Institute (EEFRI)**

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Much of the research information used in this book has been adapted from the bamboo research project on performance evaluation of introduced bamboo species at different research sites in Northwest Ethiopia (Chagnii), Southwest Ethiopia (Jimma and Tepi), Southern Ethiopia (Gambo and Wondo Genet), Eastern Ethiopia (Hirna) and Central Ethiopia (Holetta, Debrezeit), Most of the pictures of mature clumps of the introduced species are taken from web sources and the authors would like to highly acknowledge all the sources. The research has been implemented by the then Forest Research Directorate of the Ethiopian Institute of Agricultural Research that in the long run has grown up to an institutional level, the Ethiopia Environment and Forest Research Institute, by merging with other two directorates of Ethiopia Environment Protection Authority.

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This book is our first version; comments from readers, if any, are welcomed and will be duly considered while producing revised versions.

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# **Preface**

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Ethiopia has only two indigenous bamboo species namely *Arundinaria alpina* and *Oxytenanthera abyssinica*. These two species are restricted in limited agro ecological regions, i.e. in highland areas of altitude 2400-3500 m a.s.l. and in lowland areas from 500-1800 m a.s.l. Thus, with the objective of evaluating species that can grow in mid altitudes and diversifying the genetic base of the resource, different bamboo species were introduced in the country since 2007.

Some of the species introduced during the first entry (2007) were tested under field conditions in different parts of the country while the species introduced during the second entry (2009) are still at multiplication and field evaluation stage in the country. Providing full account of the already introduced species can have paramount importance in tracking and utilizing them, hence this book is devoted principally on the biological, ecological and management aspects of these species.

This book provides basic information about the introduced species under their original sites and in areas where they are found cultivated including their performance under Ethiopian testing site conditions. It is developed to support foresters and extension agents who are responsible for seedling production from prioritized species, providing training, monitoring and supporting local people. The book has three chapters: chapter one provides an overview of bamboos; chapters two deals about biological and ecological descriptions of introduced bamboo species; chapter three deals with field planting and stands management of introduced bamboo species. Propagation techniques and nursery management of bamboos is discussed in another book entitled "Propagation of Bamboos in Ethiopia, 2016" by the same authors.

<b>Table of Contents</b>	<b>Page</b>
Acknowledgements.....	ii
Preface.....	iii
Chapter I.....	1
1. Bamboo Species Diversity and Its Prospects.....	1
1.1. Overview of bamboo species diversity in the global context .....	1
1.2. Introduced bamboo species in Ethiopia .....	2
1.3. Prospects of introduced bamboo species in Ethiopia .....	6
Chapter II.....	8
2. Biological and Ecological Descriptions of Introduced Bamboo Species in Ethiopia .....	8
2.1. Introduced bamboo species evaluated under field condition .....	8
2.1.1. <i>Dendrocalamus asper</i> .....	8
2.1.2. <i>Dendrocalamus hamiltonii</i> .....	10
2.1.3. <i>Dendrocalamus giganteus</i> .....	12
2.1.4. <i>Dendrocalamus membranaceus</i> Munro .....	13
2.1.5. <i>Bambusa vulgaris</i> Var. green .....	15
2.1.6. <i>Bambusa vulgaris</i> Var. vitata .....	18
2.1.7. <i>Guadua amplexifolia</i> .....	19
2.2. Introduced bamboo species under multiplication and evaluation .....	22
2.2.1. <i>Bambusa bambos</i> Voss .....	22
2.2.2. <i>Bambusa balcooa</i> .....	24
2.2.3. <i>Bambusa multiplex</i> 'Alphonse Karr'.....	26
2.2.4. <i>Bambusa multiplex</i> Silver stripe.....	28
2.2.5. <i>Bambusa tulda</i> Roxb.....	29
2.2.6. <i>Bambusa oldhamii</i> .....	31
2.2.7. <i>Dendrocalamus brandisii</i> .....	33
2.2.8. <i>Dendrocalamus latiflorus</i> .....	36

<b>2.2.9. <i>Gigantochloa apus</i></b> .....	37
<b>2.2.10. <i>Gigantochloa kuring</i> Sumatra</b> .....	39
<b>2.2.11. <i>Gigantochloa atter</i> (Hassk.) Kurz ex Munro</b> .....	40
<b>2.2.12. <i>Guaduaangus tifolia</i> Kunth</b> .....	42
<b>2.2.13. <i>Phyllostachys pubescens</i></b> .....	44
<b>2.2.14. <i>Phyllostachys vivax</i> 'Aureocaulis'</b> .....	45
<b>2.2.15. <i>Phyllostachys aurea</i> Carrière ex Rivière &amp; C. Rivière</b> .....	47
<b>2.2.17. <i>Phyllostachys iridescens</i></b> .....	51
<b>2.2.18. <i>Schizostachyum jaculans</i></b> .....	53
<b>Chapter III</b> .....	<b>55</b>
<b>3. Field Planting and Silvicultural Management of Introduced Bamboos</b> .....	<b>55</b>
<b>3.1. Field planting</b> .....	55
<b>3.1.1. Selection and transporting of seedlings</b> .....	56
<b>3.1.2. Planting site preparation and planting in the Field</b> .....	56
<b>3.1.3. Direct planting of offset cuttings</b> .....	57
<b>3.2. Plantation maintenance and harvesting</b> .....	58
<b>3.2.1. Replanting</b> .....	58
<b>3.2.2. Plant protection</b> .....	58
<b>3.2.3. Weeding and mulching</b> .....	58
<b>3.2.4. Soil maintenance</b> .....	59
<b>3.2.5. Clump management</b> .....	59
<b>4. References</b> .....	<b>62</b>
<b>5. Glossary</b> .....	<b>65</b>
<b>6. Annex</b> .....	<b>67</b>

**List of Figures**

**Pages**

Figure 1: Testing sites of introduced bamboo species in Ethiopia during the last eight years ..... 3

Figure 2: Growth performance of *Dendrocalamus asper* at field condition at Chagnii..... 9

Figure 3: Growth performance of *Dendrocalamus hamiltonii* at Jimma three years after planting and seedling multiplication at greenhouse. .... 11

Figure 4: A mature clump of *Dendrocalamus giganteus* and seedling multiplication at greenhouse 13

Figure 5: Growth performance of *Dendrocalamus membranaceus* at Chagnii, Tepi and Holetta three years after establishment ..... 14

Figure 6: A mature clump of *Bambusa vulgaris* Var. green and performance of the species under field condition at Jimma one year after establishment..... 16

Figure 7: A mature clump of *Bambusa vulgaris* var. vitata and field performance of the species.... 19

Figure 8: *Guadua amplexifolia* growth performance at Holetta and Jimma ..... 20

Figure 9: A mature clump of *Bambusa bambos* ..... 23

Figure 10: Branch features of *Bambusa balcooa* ..... 25

Figure 11: A mature clump of *Bambusa multiplex*..... 27

Figure 12: *Bambusa multiplex* silver stripe at field condition and at its seedling stage at greenhouse condition..... 28

Figure 13: A matured clump of *Bambusa tulda*..... 30

Figure 14: A clump of *Bambusa oldhamii* and seedling multiplication at greenhouse. .... 32

Figure 15: *Dendrocalamus brandisii* growth performance at field and greenhouse..... 34

Figure 16: A mature clump of *Dendrocalamus latiflorus* ..... 36

Figure 17: *Gigantochloa apus* growth performances at Holeta at the age of two years and seedling performance. .... 38

Figure 18. A clump of *Gigantochloa kuring* Sumatra ..... 40

Figure 19: A clump of *Gigantochloa atter* ..... 41

Figure 20: Mature stand of *Guadua angustifolia* and growth performance at Holetta testing site ... 43

Figure 21: *Phyllostachys pubescens* growth performance ..... 44

Figure 22: *Phyllostachys vivax* 'Aureocaulis' ..... 46

Figure 23: A clump of *Phyllostachys aurea* Carrière..... 48

Figure 24: *Phyllostachys bambusoides* ..... 50

Figure 25: A clump of *Phyllostachys iridescens*..... 52

Figure 26: Culm features of *Schizostachyum jaculan*..... 54

# Chapter I

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## 1. Bamboo Species Diversity and Its Prospects

### ***1.1. Overview of bamboo species diversity in the global context***

Bamboos constitute one of the few selected categories of plants which are taxonomically related, very rich in species and of vital economic and ecological importance. They belong to the subfamily *Bambusoideae* and family *Poaceae* (sometimes called *Gramineae*), in the same family with cereal crops such as rice and wheat and sugar cane (Clayton, et. al., 2006).

The term bamboo comprises more than 1,500 species that are widely distributed in the tropical, subtropical and temperate regions of all continents except Antarctica and Europe, between 46°N and 47° S. Geographically bamboo distribution can be classified in to three zones: the Asian Pacific zone, the American zone and the African zone (Lobovikov, 2006). The highest diversity and area coverage of bamboo is recorded from the Asian continent, followed by America and Africa (Ohrnberger, 1999).

The sizes of bamboos vary from small annuals to giant perennial timber bamboo species (Anonyms, 2016). Dwarf bamboos may be as little as 10 cm in height, but stands of tall species may attain 15–20 m, and the largest known (e.g. *Dendrocalamus giganteus* and *Dendrocalamus brandisii*) grow up to 40 m in height and 30 cm in culm (stem) diameter (Dwivedi, 1993; Scurlock et al., 2000; Wong, 2004).

Bamboos have a long history as an exceptionally versatile and widely used resource in the world (Shanmughavel, 1997). They are eminently renewable resource; under the right conditions they display prodigious rates of growth. They grow fast and mature early. Once successfully planted, they keep on rhizoming, shooting and maturing every year. The



annual selective cutting and sustainable utilization can be implemented without damaging ecological environment.

Based on the current opinion of increasing production in cultivation and sustainably managing natural stands, prioritization studies, employing different prioritization criteria, were done by different national and international organizations. As a result, about 75% of the species are known to be used locally for one or many purposes and about 50 species are identified to be used extensively (Rao *et al.*, 1998; Annex I). A later study by Scurlock *et al.* (2000) ranked about 100 bamboo species in the 'Elite Bamboos' group, based on their significance. On the other hand, Qisheng *et al.* (2001) and NBP (1986) stated that for any climatic region, except for the extremely dry or cold, there are potentially 100's of species to choose from. Therefore evaluating adaptability bamboos in other different areas than the original growing sites and further exploitation of the resources is considerably important.

Managed bamboo forests cover more than 22 million ha of land worldwide, in addition to wild bamboo (Toensmeier, 2016). It is found distributed in wide agroecological conditions, starting from sea level to 4,000 m. Africa possesses about 40 species on over 1.5 million ha of land (Kigomo, 1988) and two of these species are found in Ethiopia (Azene, 2007). Different reports indicate that although the total forest area in many countries has drastically decreased, bamboo forest area has progressively increased during the last decades (Yiping and Zhiyong, 2013).

## **1.2. Introduced bamboo species in Ethiopia**

Ethiopia is one of the most endowed countries in bamboo resources in Africa (Kassahun, 2003). The two indigenous bamboo species in the country are the African alpine bamboo (*Arundinaria alpina*) and a monotypic genus of lowland bamboo (*Oxytenanthera abyssinica*) (Azene, 2007). Besides, twenty three different bamboo species under seven genera were introduced in Ethiopia since 2007.

The seven genera of introduced bamboo species include *Bambusa* (five species, two of them with two sub varieties each), *Dendrocalamus* (six species), *Gigantochloa* (three species), *Guadua* (two species), *Phyllostachys* (five species), *Schizostachyum* (one species) and *Thyrsostachys* (one species). The 1<sup>st</sup> entries were by the Ministry of Agriculture/the then East Africa Bamboo Project and the European Union-Energy Project/INBAR. Seven species of 1<sup>st</sup> entries namely *Denderocalamus asper*, *Dendrocalamus hamiltonii*, *Dendrocalamus giganteus*, *Dendrocalamus membranaceus*, *Bambusa vulgaris* sub. Var. green, *Bambusa vulgaris* sub. var. vitata and *bambusa balcooa* have been tested for their adaptability and growth performance in different locations (Figure 1; Table 1).

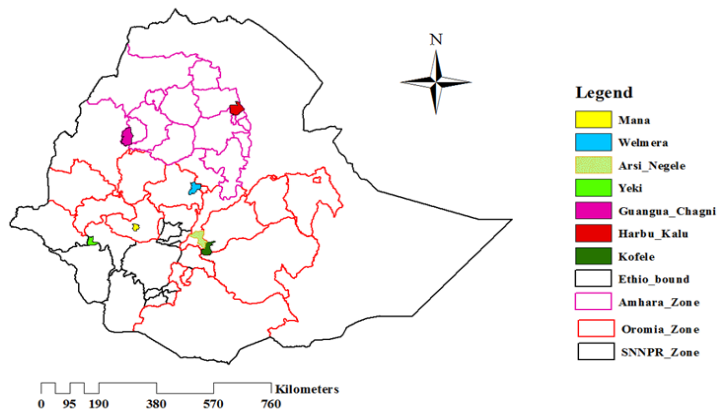


Figure 1: Testing sites of introduced bamboo species in Ethiopia during the last eight years (map developed by ZebeneTadesse).

The 2<sup>nd</sup> entries that comprise 16 species were introduced by Morel Agro-industries LTD. These species are under multiplication at Holetta and Gurd-shola nurseries of Central Ethiopia Environment and Forest Research Center, Addis Ababa. The species include *Bambusa balcooa*, *Bambusa bambos* Voss, *Bambusa multiplex* 'Alphonse Karr', *Bambusa multiplex* Silver stripe, *Bambusa oldhamii*, *Bambusa tulda*, *Dendrocalamus brandisii*, *Dendrocalamus giganteus*, *Dendrocalamus latiflorus*, *Gigantochloa apus*, *Gigantochloa atter* (Hassk.) Kurz ex Munro, *Gigantochloa kuring* 'Sumatra', *Guadua amplexifolia*, *Guadua angustifolia* Kunth, *Phyllostachys aurea*

Carrièreex Rivière& C. Rivière, *Phyllostachys pubescens*, *Phyllostachys vivax* 'Aureocaulis' and *Schizostachyum jaculans*.

Table 1. Geographic location, edaphic and climatic conditions of the testing sites

S. No	Name of testing site	Administrative location where the testing site is found			Lat-Long	Alt. (m)	Climate, Average values		
		District	Zone	Region			An.RF (mm)	Max. Temp. (°C)	Min.Temp. (°C)
1	Chagnii	Guangua	Awi	Amhara		1700	1725	28.6	13.2
2	Jimma	Mana	Jimma	Oromiya	70°46'N, 36°00' E	1753	1530	26.2	11.3
3	Holetta	Wolmera	West Shoa	Oromiya	9°N 38°30'E	2400	1040	21	6
4	Debrezeit	Ada	East Shoa	Oromiya	08° 44'N, 38° 58'E	1855	980	28.3	8.9
5	Gambo	Arsi-Negele	East Shoa	Oromiya	07°20' N, 38°49 E	2450	1250	20	15
6	Hirna	Tullo	West Hararghe	Oromiya	9° 13'N, 41° 06'E	1763	920	20	16
7	Wondo Genet	Wendogenet	Sidama	SNNP	7°19'N, 38°38'E	1920	1372	26.2	11.5
8	Tepi	Yeki	Sheka	SNNP	7°3'N, 35°18'E	1200	1678	30	15

Average values: An. RF= Annual rain fall; An. Temp. = Annual Temperature; Max.=Maximum, Min.=Minimum,; Geographic coordinates: Lat.=Latitude; Long=Longitude; Elevation: Alt.=altitude. Source: [www.eiar.et](http://www.eiar.et), accessed on May, 2016.

### **1.3. Prospects of introduced bamboo species in Ethiopia**

As described in the next sections, all the introduced species except *Bambusa multiplex*, *Schizostachyum jaculans*, and *Phyllostachys vivax* are of arborescent types that can grow 10 to 25 cm in diameter and 10 to 33 m in height. The species can be used in wood working and furniture industries substituting wood, for pulp and paper production and for construction purposes. Bamboo shoots of many of the species can be used for making delicious food stuff with good nutrient content that can be served in restaurants and at household level. The species can also be used for maintaining the environment, soil and water conservation and also for landscaping and as wind break.

The wide adoption of the introduced species will mainly be limited by their socio-economic and ecological benefits to the local community at large. But research done in Ethiopia on these species is at the very infant stage. So far, adaptability and growth performance of seven of the species has been tested and technology pre-scaling up efforts is underway. Technologies on vegetative propagation techniques are adapted and a manual on this particular topic is produced. Research on utilization aspects of the species for timber, food, feed and urban greening purposes is underway. Additionally, further research on management and utilization especially on value addition and improving the socio-economic benefits of the species to the local community is vital.

Pest and disease monitoring of the introduced species both under nursery, green house and field condition should be done as one important parameter for evaluating performance of the species in the different multiplication and testing sites. The two indigenous species of the country have superior quality for both traditional and industrial applications; performance of the species in areas other than the currently restricted locations, where the species can grow should be evaluated and promoted. In areas like Mana district of Jimma zone, Oromia region, it seems that Ethiopian lowland bamboo performs well in higher altitudes than the literally known upper elevation margin, 1800 m a.s.l.

For the species that are not tested in many locations, further evaluation of the species for their adaptability, growth performance and pest and disease resistance should continue. Simultaneously, continual multiplication of the species is very required.

## Chapter II

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### 2. Biological and Ecological Descriptions of Introduced Bamboo Species in Ethiopia

#### 2.1. Introduced bamboo species evaluated under field condition

As indicated in the previous sections, there are many bamboo species introduced in Ethiopia and evaluated in different locations for their adaptability and growth performance. Biological and ecological information reviewed from different sources and the already generated information from field trials is compiled and presented here under for each of the seven species tested.

##### 2.1.1. *Dendrocalamus asper*

**Local name:** Sweat Bamboo (English), Thaitama Bans (Sikkim, India). **Common name:** Giant bamboo.

**Synonyms:** *Dendrocalamus asper* is also called *Bambusa aspera*, *Gigantochloa aspera*, *Dendrocalamus flagellifer*, *Dendrocalamus merrillianus*.

**Description:** *Dendrocalamus asper* is a giant tropical and subtropical clumping and evergreen bamboo species native to Southeast Asia. It has a short and thick rhizome and densely tufted erect culms. Culms are 15 - 30 m tall and 8-20 cm thick with internode length of 40 - 50 cm. This species has performed well (Figure 2) at Chagnii (Northwest Ethiopia) with total biomass accumulation of 131 kg/clump (82 t/ha) at the age of four.

**Culms:** hollow but thick walled, young culms densely pubescent, matured culm very large and very strong and durable, swollen nodes, upper

internodes longer than the lower, internodes at culm base very short, lower nodes with many aerial roots.

**Culm sheaths:** caduceus in old, sheath ligules narrow and wavy, sheath blade ovate lanceolate.

**Leaves:** 5-9 on each twig, pseudo spikelets often in spherical dense clusters at the nodes of leafless branches. Leaf 30 x 2.5 cm.



Figure 2: Growth performance of *Dendrocalamus asper* at field condition at Chagnii (four years after planting, left), seedling multiplication at greenhouse of Central Ethiopia EFRC (right)

**Flowering and fruiting:** inflorescence long, flowers sterile, fruits collected from hybrids. This species flower gregariously. The flowering cycle is 30-40 years.

**Distribution:** Commonly planted in Thailand, Vietnam, Malaysia (Peninsular and East), Indonesia and the Philippines; commercially important in eastern parts of India; widely introduced elsewhere in tropical and subtropical botanic gardens, origin somewhere in South East Asia. This species grows best in rich and heavy soils of the humid regions. Altitude ranges from lowlands to 1500 m in other countries but in Ethiopia it is found performing well at 1700 m a.s.l. at Jimma and Chagnii with rain fall and temperature indicated in Table 1 above. This species also grows well in semi-dry areas in Thailand with good drainage and tolerates temperature up to  $-3^{\circ}\text{C}$ .



**Silvicultural management:** This species is found widely cultivated in tropical regions. It is vegetatively propagated by using culm and branch cutting and offset techniques.

**Uses:** This species is mainly cultivated for edible shoot apart from its use for construction, paper and pulp, pole, etc. There is clear potential for use of this species in agroforestry systems and also for use in manufacturing bamboo boards. It is also used as a structural timber, strong, large, very good quality and one of the most useful bamboos for heavy construction in rural communities. However, it is mainly used for building due to the strength of the culms which are relatively durable. It is also used in making good quality furniture, musical instruments, containers, chopsticks, household utensils and handicrafts. The young shoot is sweet and considered delicious.

### **2.1.2. *Dendrocalamus hamiltonii***

**Local name (Indian names):** Kako/Hate (Arunachal Pradesh); Kakobanh (Assam); Unap (Manipur); Aotsü (Ao-Nagaland); Choya Bans/Ban Bans/Dhungra bans (Sikkim) Phulrua (Mizoram); Pecha (Tripura).

**Synonyms:** *Hamilton's Bamboo*

**Description:** *Dendrocalamus hamiltonii* is a large bamboo, evergreen or deciduous, densely clumping or caespitose, sometimes growing tall and erect, but more often sending out its stems at an angle or curved downwards. At the age of four years after establishment from seedling, the species attained an average height of 10 meter and average culm diameter at breast height of 3.4 cm (Figure 3) with an average dry weight of 82.16 kg/clump at Jimma. The dry weight estimate four years after establishment at Chagnii was 103.47 kg/clump (65 t/ha) at Chagnii. It can be assumed that the clump attains more biomass as it gets matured. This species has big size and enormous number of leaves that constitute about 20% of the total biomass of the clump (Asabeneh and Yigardu, 2015). The number of culms per clump at Gambo (Southern Ethiopia) four years after establishment was 34.

**Culms:** large, 12-20 m or up to 25 m tall, 10-18.5 cm diameter, usually naked below, much branched above. Internodes 30-50 cm long, culm wall 1-2 cm thick, nodes marked with root scars.

**Culm sheath:** is long and stiff, variable in size, those of lower part of large culm 35-45 cm long, about 20 cm broad.

**Leaves:** variable, small on side branches, but on young plants they reach 37.5 cm long and 3.5 cm wide, rounded at the base into a short thick petiole; leaf sheath covered with white, appressed stiff hairs.



Figure 3: Growth performance of *Dendrocalamus hamiltonii* at Jimma three years after planting (left) and seedling multiplication at greenhouse at Central Ethiopia EFRC (right).

**Flowering and fruiting:** inflorescence dense panicle especially at the tip, with purple spikelet, fruits ovoid, broad. This species usually flowers sporadically every year, sometimes gregariously and the flowering cycle is reported to be 30-40 years.

**Distribution:** in tropical and sub-tropical climatic zone and prefers hill terrains. Often cultivated in rich loams soil and moist places. Distributed in Asia-temperate (China), Asia-tropical (India and Indo-China).

**Silvicultural management:** This species can be propagated by rhizome or offset planting, culm cuttings and also from seeds. Serious incidences of damages by pest and diseases have not been observed on this species.

**Uses:** *Dendrocalamus hamiltonii* is a locally available variety of multipurpose bamboo which is mainly cultivated as wood substitute, fodder; the edible shoots is used for making pickles and preparing drinks. It is also highly appreciated by woodworking and furniture industry. This bamboo is one of the commonly used species in Assam and Nagaland. It is used for construction, making of basket, mats, ropes, as container for water, milk and other food items. It is also used in paper and pulp industries in large quantity.

### **2.1.3. *Dendrocalamus giganteus***

**Local names (Indian names):** Worra (Arunachal Pradesh); Bor Kako (Assam); Maribob (Manipur); Bhalu Bans (Sikkim); Warok (Ao-Nagaland); Rawnal (Mizoram).

**Synonyms:** *Sinocalamus giganteus*

**Description:** The largest of the bamboos and densely caespitose.

**Culms:** over 30 m tall, 15-25 cm in diameter, often naked at the base (Figure 4), branchy above, nodes hairy; internodes 37-40 cm long, covered with white waxy scurf when young. Culm sheath is as broad at the base as at the summit, 25-50 cm long, glabrous within, clothed with golden or brown hairs, often recurved, wavy auricles.

**Leaves:** large, broadly lanceolate, rounded at the base, 30-50 cm x 1-1.1 cm, cuspidate acuminate, at first hairy, afterwards glabrous, sheaths striate, ligule long.



Figure 4: A mature clump of *Dendrocalamus giganteus* (left, source: Anonymous, 2016); seedling multiplication at greenhouse of Central Ethiopia EFRC (right)

**Flowering and fruiting:** So far gregarious flowering of this species has not been reported. Flowering cycle is 40 years.

**Distribution:** This is a species of tropical and sub-tropical climate and grown in loamy soil. This species is native to Malaya and Myanmar, cultivated in India and frequently cultivated in North eastern state and west Bengal.

**Silvicultural management:** This species is propagated by rhizome or offsets planting, cuttings and also by seeds. Damage caused by pest and disease pest has not been reported so far and it appears to be negligible.

**Uses:** In north eastern India, the culms are widely used for house building, fencing, as container and various decorative items. In Arunachal Pradesh Mishmi tribe use this bamboo mainly as water container. It is also better raw material for paper and pulp.

#### **2.1.4. *Dendrocalamus membranaceus* Munro**

**Local names:** Waphyu (Yezin, Myanmar), Unankhong dangbi (Manipur).

**Synonyms:** *Bambusa membranacea* Stapleton & N. H. Xia; *Dendrocalamus longifimbriatus* Gamble; *Sinocalamus longifimbriatus* (Gamble) T. Q. Nguyen; *Oxytenanthera lacei* Gamble.

**Description:** A large bamboo with small leaves, and a very branchy and bushy growth habit. The small leaves give it a 'fluffy' appearance which makes it look great when viewed from a distance. The average number of culms per clump 4 years after establishment from seedling at Jimma (Southwest Ethiopia) was 42 and the average height at the same age was 7 m. It has an average total dry weight of 76 kg per clump at Jimma and 45 kg per clump at Chagnii 4 years after establishment. This species was also tested in other sites and showed good performance (Figure 5).

**Culms:** are straight with weeping tops, 20–25 m high, 6–10 cm diameter, covered with white powdery material; nodes prominent with rings, basal nodes with rootlets, internodes up to 40 cm long.

**Culm-sheaths:** 30–50 cm long and 12–20 cm broad, glabrous outside or with appressed dark-brown hairs, narrowed upwards; ligule about 5 mm high, dentate; auricles 2, wavy, fringed; blade 25–40 cm long and 2–3 cm broad, tapering.

**Leaves:** Leaves 25 x 2.5 cm, hairy on midrib and beneath; inflorescence compound panicle, with distinct globular heads on nodal points, spikelets closely grouped.



Figure 5: Growth performance of *Dendrocalamus membranaceus* at Chagnii (left), Tepi (middle) and Holetta (right) three years after establishment

**Flowering and fruiting:** Flower structure variable; fruit ovate, flat, 5–8 mm long; flowering habit gregarious.

**Distribution:** Its natural habitat is a tropical mixed deciduous or monsoon forest below 1000 m elevation and is one of the most frequently

occurring, clump-forming woody bamboos. It is naturally distributed in Laos, Myanmar, Northern Vietnam, Northern Thailand, China (Yunnan Province).

**Silvicultural management:** It can be propagated by rhizome or offset planting, culm cuttings and also by seed.

**Uses:** It is used for construction, good quality furniture, paper and pulp, chopsticks and handicrafts; the species has great potential for cultivation in plantations and edible shoots of very good quality. It is also used for rayon and paper raw material, flooring parquet, in house decorations and mats for export. Shoots of *D. membranaceus* is delicious food stuff with high content of nutrients (percentages in dry matter). Total sugars 20.7%, total N of 5 3.10%, protein 19.37%, amine acids 2.10%, cellulose 28%, vitamin C 167.20 mg/ 100g. As a priority species, this bamboo has been crucial in efforts toward the protection of local soils and biodiversity.

#### **2.1.5. *Bambusa vulgaris* Var. green**

**Local name (Indian names):** Telabanh/Tanstibanh (Assam); Lam-Saneibi /Babal/Basni (Manipur); Bheriu (Meghalaya); Bakal (Bengal); Vairui (Mizoram); Jai (Tripura).

**Synonyms:** *Arundarborblancoi* (Steud)

**Description:** A moderate sized bamboo not densely tufted and open clumping, sympodial bamboo (Figure 6). Culm erect, sinuous or slightly zig-zag, *Bambusa vulgaris* var. green has 66 culms/clump at Jimma22 new shoot recruitment per clump four years after establishment. The average total dry weight was estimated at 90 kg per clump at Chagnii and 76 kg per clump at Jimma four years after establishment.

**Culms:** 8-20 m high, 5-10 cm in diameter, bright green, glossy, erect, matured culm yellowish, walls 7-15 mm thick, branching usually from mid-culm to top; nodes prominent, lower ones often with a narrow ring of roots, usually covered with brown hairs; inter nodes up to 15cm long. Young shoots dark brown to yellowish green.

**Culm-sheaths:** 15-25 cm long and 25-35 cm broad, rounded and truncate at top, often beautifully streaked when young with green and yellow, strait, adaxial surface densely covered with thick appressed brown black hairs, edges ciliate; ligule 5-8 mm tall, continuous with the top of the sheath, dentate or sometimes entire, margin ciliate; auricle 2, sub equal, continuous with the blade; blade somewhat triangular, bright yellow, acute, 5-15 cm long and up to 10 cm broad.

**Leaves:** narrow or broadly lanceolate, 15-25 cm long and 2-4 cm broad rounded or attenuate at the base into a 5 mm long petiole, glabrous on surfaces, occasionally sparsely hairy when young, margin scabrous.



Figure 6: A mature clump of *Bambusa vulgaris* Var. green (left, sources: Anonymous, 2016; Stephone Schroder, 2011) and performance of the species under field condition at Jimma one year after establishment from seedling (right)

**Flowering and fruiting:** It flowers sporadically. Inflorescence panicle, with many spikelets, no seeds. It is propagated by vegetative propagation methods such as culm cuttings, rhizome planting, branch cutting, layering, marcotting.

**Distribution:** *Bambusa vulgaris* var. green is a pan tropical species. Origin of the species is unknown but most commonly cultivated everywhere in naturalized populations in North East India and natural forest in central India. This is commonly grown in homesteads and garden as ornamental plant.

It grows in a wide range of climates and on a range of soils; up to about 1500 m a.s.l., in other countries but in Ethiopia it is found performing well at altitude of 1753 m a.s.l. at Jimma and 1700 m a.s.l. at Chagnii (Figure 6). It is frost hardy up to  $-3^{\circ}\text{C}$ , drought resistant and very vigorous on moist soil (PROTA, 2014). The species prefers moist soil and thrives at the periphery of cultivated land, creeks and foot-hills and requires tropical climate. It grows in almost permanently humid conditions along rivers and lakes, but also in areas with a severe dry season, where the plants may become completely defoliated. It is partially tolerant to waterlogged and salinity conditions. The species grows best in well-drained soils with pH ranging from 4.5 to 7.5 (Francis, 1993; Dransfield and Widjaja, 1995).

**Silvicultural management:** This species is one of the fast growing bamboo species preferred for raising plantation. It is easy to propagate by using rhizome, culm branch cutting and layering. Pest and diseases identified include blight by *Sarocladium oryzae*, basal culm rot by *Fusarium sp*, culm sheath rot by *Glomerellacin guleta*, leaf rust by *Dasturella divina*, and leaf spot by *Dactylaria sp*. These can be controlled by removal of affected culm and application of fungicides.

**Uses:** *Bambusa vulgaris* is widely planted and used for a variety of purposes, primarily for light construction such as houses, huts, boats (masts, rudders, outriggers, boating poles), fences, scaffolding, furniture, musical instruments and handicrafts. This species is also commonly used for pulp and paper industries; young shoots are edible but of average to poor quality. Culms are also used as carrying poles or banana plant supports.

Split stems are used for brooms, baskets, and rings prepared from the split culms are put into ear perforations by the Tunkul-Naga tribes of Manipur. In New Guinea, culms are used to make traditional combs and penis gourds in the phallocrypt tradition. Leaves are sometimes used as forage or livestock fodder although toxic effects to horses were noted. It is also used as medicine, chloroform extract of the leaves is used against *Mycobacterium tuberculosis*. Tabasheer from culm internodes is used to treat



infantile epilepsy, fever and hematuria, kidney troubles, bark astringent and emmenagogue (to stimulate or increases menstrual flow), and as an abortifacient (to cause abortion). *Bambusa vulgaris* is often planted as an ornamental bamboo or to form hedges to border land. It can be planted on slopes to control erosion.

#### **2.1.6. *Bambusa vulgaris* Var. *vitata***

**Local name:** Lunas (Tagalog, Philippines). **Common name:** Clumping Bamboo, Common Bamboo, Painted Bamboo.

**Synonyms:** *Bambusavulagaris* var. *aureo-variegata*

**Description:** It has lemon-yellow culms (stems) with green stripes and dark green leaves (Figure 7). The densely tufted culms grow 10–20 m high and 4–10 cm in diameter.

**Culms:** Stems are not straight, not easy to split, inflexible and initially strong. They are basally straight, bent alternately in different directions, drooping at the tips. Culm walls are slightly thick. Nodes are slightly inflated. Internodes are 20–45 cm long. Culm leaves are deciduous with dense pubescence.

**Culm sheaths:** The culms often emerge green with a sheath covered with dark brown hairs.

**Branches:** Many clustered branches, with one larger dominant branch, develop from mid-culm nodes and above. They are often striped.

**Leaves:** Narrow lance-shaped leaves which are on average 15–20 cm long and 2–2.5 cm wide.



Figure 7: A mature clump of *Bambusa vulgaris* var. *vitata* (left, photo by Mr. Tesfaye Hunde) and field performance of the species propagated using culm cutting.

**Flowering and fruiting:** At the interval of several decades, the whole population of an area blooms at once, and individual stems bear a large number of flowers, but fruits are rare due to low pollen viability caused by irregular meiosis. The clump survives after the culms die after flowering.

**Silvicultural management:** It can be propagated vegetatively by clump division, rhizome, culm and branch cuttings, layering and marcotting. The easiest and most practiced propagation technique is culm or branch cutting. In the Philippines, the best results were obtained from one-node cuttings from the lower parts of six-month-old culms. When a stem dies, the clump usually survives.

**Uses:** Culm is used for poles, fences, props, stakes, or posts. Its rhizomes extend up to 80 cm before turning upward to create open, fast-spreading clumps. The easy propagation of *B. vulgaris* explains its seemingly wild occurrence.

### **2.1.7. *Guadua amplexifolia***

**Local names:** guafa (Venezuela), guaduilla (Colombia) and Yucatan (Mexico).

**Synonyms:** *Bambusa amplexifolia*

**Description:** Rhizome is pachymorph (sympodial); thorny, tropical clumping bamboos native to the New World (North and South America).

Clumps are very open. The species showed lower performance as compared to other bamboo species in Ethiopia (Figure 8) with an average height of 3 m, average diameter of culm 2.83 cm at the age of 4 at Jimma. It had 76 cm shoot sprout height, and 34 shoots produced at Gambo on average at the age of five. It had 11.90 kg of dry weight per clump at Jimma and 45.30 kg per clump at Chagnii at the age of four.

**Culms:** are erect tapering reached height of 10-20 m and diameter of 6 -10 cm. Inter node are thick walled or solid. The species bears thorns on its branches. Culm-internodes terete; with small lumen, or solid; mid-green; distally glabrous. Lateral branches dendroid. Short internodes, nearly solid in the lower part of the arching culms. It has a solid culm in the base and a small lumen in the distal part.

**Culm-sheaths:** Glabrous; without auricles, or auriculate; setose on shoulders; shoulders with 4-8 mm long hairs. Culm-sheath blade lanceolate; 5-20 cm long; brown pubescent.

**Leaves:** Are evergreen and leaf length reached 16-24 cm. Leaf-sheaths are glabrous on surface and oral hairs setose. Leaf-sheath auricles falcate is 20-35 mm long. Ligule an eciliate membrane is 0.5 mm long. Collar with external ligule. Leaf-blade base with a brief petiole-like connection to sheath. Leaf-blades lanceolate; 16-24 cm long; 30-51 mm wide. Leaf-blade surface glabrous. Leaf-blade apex acuminate.



Figure 8: *Guadua amplexifolia* growth performance at Holetta (left) and Jimma (right)

**Flowering and fruiting:** This species flowers gregariously every 25 years and dies after flowering. Inflorescence: bractiferous; clustered at the nodes; in untidy tufts; lax; with glumaceous subtending bracts; prophyllate below lateral spikelets; leafy between clusters. Fertile spikelets sessile, comprising 6–10 fertile florets; with diminished florets at the apex. Spikelets linear; laterally compressed; 35–60 mm long; 4–5 mm wide; breaking up at maturity; disarticulating below each fertile floret. Glumes: several; 3–4 empty glumes; persistent; shorter than spikelet. Upper glume ovate; 4–8 mm long. Florets: fertile lemma ovate; 14–16 mm long; coriaceous; without keel; 21–25 -veined. Lemma surface glabrous, or pilose; lemma apex apiculate. Palea keels winged; conspicuously winged; ciliate. Apical sterile florets resembling fertile though underdeveloped.

**Distribution:** This plant has been said to grow in Loxahatchee, Florida regions. It occurs in greatest abundance in eastern Nicaragua, in a narrow but more or less continuous band along the rivers emptying into the Caribbean between Puerto Cabezas and Bluefields. Occasionally, it occurs in openings in the forest either as pure stands or mixed with trees and shrubs.

**Silvicultural management:** It can be propagated by dividing rhizomes, tubers, corms or bulbs (including offsets). Good performance is achieved by supplying stands with natural water sources and by allowing good drainage so that the soil is maintained moist but not flooded.

**Uses:** Of all the giant species of genus *Guadua* this species is the less useful and it is not recommended for construction because it is easily attacked by insects. It has an environmental benefits because they function as carbon sinks, produce oxygen, control soil erosion, provide organic matter, regulate water levels in watersheds, conserve biodiversity.

## 2.2. Introduced bamboo species under multiplication and evaluation

### 2.2.1. *Bambusa bambos* Voss

**Local name (Indian names):** Katabah (Arunachal Pradesh); Kotoha/Kotabanh (Assam); Saneiba (Manipur); Kanday bans (Sikkim); Thorny bamboo (English)

**Synonyms:** *Arundo bambos* L., *Bambusa arundinacea*

**Description:** *Bambusa bambos*, the Indian thorny bamboo, is a very dense tufted bamboo, producing large dense clump of closely packed culms (Figure 9). Performance of this species under nursery level in highland areas of Central Ethiopia (Gurd Shola and Holetta) is not promising.

**Culms:** Strong, cylindrical, erect, hollow, dark green-colored up to 30m tall, 15-18 cm diameter, the wall very thick with a lumen; branching at all nodes, those from the lower nodes re curved and bend downward towards the ground with the upper branches arching and producing a fan like plume, the upper leafy branches bearing small spines. Nodes slightly swollen and few lower nodes produce short aerial roots. Nodes contain a single branch bud at the ridged nodal line. The central dominant branch is produced first with one or two lateral branches from the lower nodes, usually the primary and one secondary branch produced at the lower nodes of the culm.

**Culm sheath:** Are coriaceous, glabrous to pubescent with dark brown velvety hairs.

**Leaves:** Diffuse in complements, 15-30 cm long and 8-15mm broad, with about 10 leaves in each complement. Leaf blades linear and variable in size, lanceolate, narrowed to an acuminate tip, with mid-vein inconspicuous on the abaxial side and prominent on adaxial side.



Figure 9: A mature clump of *Bamusa bambos* (source: Anonymous, 2016)

**Flowering and fruiting:** This species flower gregariously and clump dies after flowering. The flowering cycle is 30 -to 45 years.

**Distribution:** Native to southern Asia (India, Bangladesh, Sri Lanka, Assam, and Indochina). It is found throughout India up to 1200 m altitude. This species prefer sandy loam and fertile soil with tropical to sub-tropical climatic conditions.

**Silvicultural management:** Natural regeneration occurs from seeds after gregarious flowering. Seeds have no dormancy and help to utilize the favorable condition after seed fall. Artificial regeneration can be made by collecting seeds by sweeping the ground under flowered clumps and cleaning the seed by winnowing. Protection from grazing and fire is very much essential during the seedling stage for proper establishment.

Leaf blight, leaf spot, stem infection, damping off, rhizome bud rot, rhizome decay, culm rot, basal culm decay, leaf rust, sooty mould by differed pathogen have been reported in this species. These can be controlled by adopting appropriate silvicultural management practices such as thinning out diseased, infected and matured culm from the stand. Proper sanitation measures should also be adopted to control fungal attack. Animals like Porcupines, rats, pigs, elephants, squeals, hares, deer, goats etc. also cause considerable damages in bamboo plantation.

Therefore proper fencing and protection should be provided around the plantation site especially during the seedling stage

**Uses:** This bamboo is utilized as raw material for paper, house construction, panel production and fencing. It is also used for scaffolding, handy craft, furniture, cooking utensils, etc. Shoot is used as vegetable and leaves as fodder and medicine.

### **2.2.2. *Bambusa balcooa***

**Local names (Indian Names):** Bhaluka(Assam), Balku bans (West Bengal), Boro bans (North Bengal), Wamnah, Beru(Meghalaya), Barak (Tripura). It is also known as Female Bamboo.

**Synonms:** *Dendrocalamus balcooa* (Roxb.)

**Description:** *Bambusa balcooa* is a tropical clumping bamboo that can grow up to a height of 25 m and a diameter of 15 cm.

**Culms:** are grayish green and thick walled; diameter of the cavity is about one-third of that of the culm. Nodes are thickened with a whitish ring above, and have short small hairs below. Culm internodes are on average between 20 and 40 cm long. Culm sheaths are brown or orange tinged, covered sparsely with dark brown hairs.

**Branches:** Several clustered branches with 1-3 larger dominant branches grow on culm nodes. They occur from middle of the culm to the top. Branches from the lower nodes are leafless and hard and sometimes thorn-like (Figure 10).

**Leaves:** Are narrow, on average 15-30 cm long and 25-50 mm broad.



Figure 10: Branch features of *Bambusa balcooa* (source: Anonymous, 2016)

**Flowering and fruiting:** Gregarious flowering and seed-setting usually occurs every 35-45 years, flowering was last reported between 1983-1988.

**Distribution:** Originated from Northeast India. It is native to Assam, lower Bengal and Biha. It grows up to an altitude of 700 m in tropical monsoon climates with an annual rainfall of 2,500 - 3,000 mm. It grows on any type of soil but prefers heavy textured soils with good drainage and a low pH of about 5.5.

**Silvicultural management:** *B. balcooa* can be propagated vegetatively by rhizome, culm and branch cuttings. Root formation in culm cuttings is effectively promoted by treatment with growth regulators like naphthalene acetic acid (NAA), but auxin and kinetin are most effective in two nodal branch cuttings that are 1 year old. Young plants need watering when rainfall is not sufficient. The propagules are raised in a nursery and after they have produced roots and developed rhizomes they are planted out in the field during the rainy season in pits filled with a mixture of cow dung and soil, at recommended distances of 4-5 m x 4-5 m. An annual production of 1200-1700 culms/ha is reported from Bangladesh.

In Bangladesh a serious disease of this species is bamboo blight, attacking young bamboos during or soon after the elongation growth and resulting



in dieback. 3 (*Acremonium strictum*) is the main fungus associated with blight symptoms, but the causal agent is not yet known. Insects spread the disease within a culm but also to other culms.

Improvement of cultural practices (burning of infested parts, mulching and covering clumps with soil before the rainy season, not over harvesting culms) promotes the growth of more healthy and vigorous culms in clumps, and such culms are less susceptible to blight. Drenching the soil of affected clumps with fungicide (e.g. fytolan 0.45 or dithane M45 0.4%) before the rainy season also promotes survival of new culms. Culms are less susceptible to blight.

**Uses:** Stems are used as a building material for houses, bridges, fishing floats, is much used for scaffolding, and frames of rickshaw hoods, baskets, woven mats and for agricultural and fishing implements. This bamboo species also serve as a raw material for the wood chip industry, paper pulp, shoots are consumed as a vegetable and leaves are used as fodder. Young shoots are used as a vegetable. In Bangladesh, leaves are used as emergency fodder. The culms are used as building material for houses, bridges, temporary fishing floats, frames of rickshaw hoods, to prepare agricultural and fishing implements and to weave mats and baskets. In India the culms also serve as raw material for paper.

### **2.2.3. *Bambusa multiplex* 'Alphonse Karr'**

**Local names:** Phaisichomphu (Thai), "sichomphu" means pink color.  
**English name:** Alphonse Karr, Hedge Bamboo. **Common name:** Alphonse Karr.

**Synonyms:** *Bambusa alphonso-karrii* Mitford ex Satow; *Bambusa multiplex* f. *alphonso-karrii* (Mitford ex Satow) Nakai.

**Description:** A dense, clumping bamboo with culm height of 7.6 - 10.7 m and diameter of 1.27 to 2.54 cm. The culms on this bamboo are golden with random green stripes of variable width (Figure 11).

**Culms and Branches:** are striped green or yellow. They are bright yellow with irregular narrow dark green longitudinal stripes; new shoots are reddish. It branches at culm nodes from base to the top. New culms have a pink cast.

**Leaves:** are fairly large and remain lush green.



Figure 11: A mature clump of *Bambusa multiplex* (left, source: <http://www.bambooweb.info>) and at Holetta (right, photo by Belayneh Azene).

**Flowering and fruiting:** Not documented.

**Distribution:** It is occasionally found cultivated in Thailand. Minimum Temperature is as low as 18°F.

**Silvicultural management:** plant in full sun to light shade; hardy to 12 °F. Tolerance to full sun makes it versatile. Follow a regular watering schedule during the first growing season to establish a deep, extensive root system. Watering can be reduced after establishment. Add a general purpose fertilizer before new shoots begins to grow during the shooting season. As a hedge, it can be maintained at 2.4 to 3 m tall with occasional pruning.

**Uses:** The beautiful striped bamboo culms are used for furniture making. Dried poles of Alphonse Karr bamboo tree can be used ornamentally in handicrafts. It is one of the best hedge bamboos. This bamboo makes a wonderful container plant. Like other forms of *Bambusa multiplex*, it is

among the best bamboos for a well-lit area indoors. It is an excellent choice for a privacy screen where a clumping bamboo is desired.

#### 2.2.4. *Bambusa multiplex* Silver stripe

**Local name:** *Silver stripe Bamboo (China).*

**Synonym:** *Bambusa multiplex 'Variegata', Bambusa nana 'Variegata', Bambusa glaucescens 'Silverstripe'*

**Description:** A vigorously clump forming bamboo with culm height of 13.7 m and diameter of 3.81 cm. It is a very tight clumper, being nearly impenetrable once established.

**Culms:** Are occasionally white striped. Some of the culms twist up to 90 degrees between nodes.

**Leaves:** New leaves have white stripes (Figure 12). That is what gives this particular strain of *Bambusa multiplex* the name "Silverstripe."



Figure 12: A clump of *Bambusa multiplex* silver stripe (source: Anonymous, 2016) at field condition (left) and at its seedling stage at greenhouse condition at FRC (right).

**Flowering and fruiting:** This bamboo flowering gregariously and weakens the plant.

**Distribution:** Multiplex has been a landscape fixture for decades in many southeastern states. It is often found surrounding the perimeter of old homesteads, especially in Florida.

**Silvicultural management:** Plant in full sun to light shade. Hardy to 12 °F. It tolerates minimum temperature as low as 18°F. Some thinning is recommended for the older culms to allow for new, larger culms to grow up in the middle. This species propagates easily using the whole culm burial method (whole culm method).

**Uses:** It is used to make an excellent privacy hedge. It is among the best bamboos for interior use.

### **2.2.5. *Bambusa tulda* Roxb**

**Local Name (Indian Names):** Jati /Mirtinga/Wati (Arunachal Pradesh); Jati (Assam); Owati (Meghalaya); Koraincho bans (Sikkim); Longmeii (Ao-Nagaland); Rawthing (Mizoram). Common name: Bengal bamboo

**Synonym:** *Denderocalamus tulda*.

**Description:** A large clump-forming bamboo (Figure 13) and is considered to be one of the most useful of bamboo species in the world. It is an evergreen or deciduous bamboo with culm 6 - 20 m tall. The thin-walled culms are about 5 - 10 cm in diameter.

**Culm:** smooth; internodes 40-70 cm long with internodes 36 - 60 cm long.

**Culm sheath:** 20-25 cm long and broad, nearly glabrous, rounded at tip, black inside; blade 10-15 cm long, triangular, cuspidate, appressed hairy beneath, rounded at base; ligule 2 mm high, white hairy outside.

**Leaves:** 20-35 cm long and 3-4 cm broad, oblong-lanceolate, base oblique, petiole short; leaf-sheath glabrous or sparsely hairy, ligule short.



Figure 13: Matured clump of *Bambusa tulda* (Source: Gamble, 1896)

**Flowering and fruiting:** This species flower gregariously. The flowering cycle is 30 to 60 years. Under ambient conditions, the seed remains viable for about 1 month only; when stored dry (in a desiccators over silica gel) viability can be extended to up to 1.5 years.

**Distribution:** Distributed widely in North Eastern India and West Bengal. This species occurs at an altitude of 1500 m. it prefers moist alluvial soil in good rainfall areas and fine textured soil in semi evergreen forest, in relatively low rainfall areas with sub-tropical to temperate climatic condition. It grows best in areas where annual daytime temperatures are within the range 22 - 28°C, but can tolerate 9 - 32°C. It prefers a mean annual rainfall in the range 1,200 - 2,500 mm, but tolerates low rainfall down to 700mm. Grows best in fertile, medium to heavy soils. Prefers a pH in the range 5 - 6, tolerating 4.5 - 6.5.

**Silvicultural management:** The seeds exhibit orthodox behavior and can be stored by proper control of moisture content and temperature. Vegetative propagation like rhizome and culm cutting are successfully practiced for propagation of this species apart from seeds. The seedlings raised from culm cuttings can be successfully multiplied by shoot proliferation. As per felling rules, felling cycle four years is suggested. This

species is one of the high yielding bamboo suggested for large scale plantation.

The sap sucker *Oregmabumbusae* which causes the wilting and death of young shoots has been reported to be pest for this species. Bavistin, BHC powder or dieldrin or aldrin (0.5% solution or powder) are effective controls. Fungal infection also affects the yield and quality of pulp. The species is also affected by blight caused by *Sarocladiumoryzae*. This can be controlled by cultural practice and application of Dithane M 45 as soil drench.

**Uses:** It is favored for handicraft, paper and structural purpose. It is strong bamboo; it lends itself easily to mechanized processing, and is being used for making bamboo boards and composites.

#### **2.2.6. *Bambusa oldhamii***

**Local name:** *Giant timber bamboo* (English). **Common name:** *Giant timber bamboo* or Oldham's bamboo.

**Synonyms:** *Lelebaoldhamii*, *Sinocalamusoldhamii*, *Dendrocalamop sisoldhamii*, *Bambusa atrovirens*, *Dendrocalamop sisatrovirens*.

**Description:** *Oldhamii* (*Bambusa oldhamii*) is a large clumping bamboo growing up to 20 m in height and 10 cm in diameter in good conditions.

**Culms:** are straight and erect (Figure 14). Culm leaves promptly deciduous, oblong, initially brown-sericeous, becoming glabrous, rounded distally; auricles absent or very small and rounded; fimbriae few, to 3 mm, curved; ligule to 2 mm, entire or finely serrulate; blades broadly subtriangular, usually with concave margins, abaxial surfaces glabrous, adaxial surfaces antrorsely hispid, apices acuminate.

**Branches:** Are very short, not thorny, the central branch at each node often tardily developed, branches not developing from the lower nodes, branchlets of the lower branches not thornlike.

**Leaves:** The large leaves of this bamboo give it what some would call a tropical look. Leaf sheaths are striate, glabrous or sparsely hispidulous, margins very shortly ciliate; **auricles** very small, rounded; **fimbriae** many, to 5 mm, fine, wavy; **ligules** to 1 mm, truncate, glabrous, entire; **blades** 15–30 cm long, 3–6 cm wide, oblong-lanceolate, abruptly acuminate, abaxial surfaces pubescent initially, becoming glabrous, adaxial surfaces glabrous.



Figure 14: A clump of *Bambusa oldhamii* (left, Anonymous, 2016) and seedling multiplication in greenhouse of Central Ethiopia EFRC (right).

**Flowering and fruiting:** Jolla (1993) and Encinitas (1995) noted that flowering incidents of this species could be stress induced.

**Distribution:** Native to low-lying areas of eastern China and Taiwan. It is the most commonly grown large, clump-forming bamboo in the United States, where it is grown mostly in Florida and California. With its upright culms and short branches it makes an excellent tall hedge.

**Silvicultural management:** *Oldhamii* is one of the most popular bamboos in cultivation. It best grows in full sun and is very drought hardy and self-sufficient when established. It is propagated from seed, sowing it in a greenhouse around 68 °F in a moist compost. Germination can take up to six months, but is usually much sooner. Grow seedlings in light shade until large enough to plant.

**Cultivation:** Giant timber bamboo plants need a humus-rich soil with a pH range of 5.5 to 6.5. The best location is one that receives dappled shade

to full sun. Dig a hole slightly larger than the size of the pot or seedling, and back fill the hole with a 50/50 mix of native soil and mature compost. Provide regular, deep watering with a soaker hose or drip irrigation, the equivalent of an inch of rain per week for the first year, more during hot spells. Prune away dead culms as needed, and after the third growing season, prune undersized or unruly culms to match the desired height and appearance.

**Pests and Diseases:** This bamboo is generally resistant to pathogens, but susceptible to insects like aphids, scale and mealy bugs. Although these pests don't harm the plant in most cases, they can secrete a sticky honeydew that leads to an unsightly black mold. Organic controls include insecticidal soaps and neem oil. Mealy bugs may require a systemic pesticide. Prevent infestations by avoiding over-fertilizing with chemical fertilizers that make the bamboo more attractive to pest insects.

**Uses:** It is a giant timber bamboo. The culms are very straight and strong, making it one of the best bamboos to build from. *Oldhamii* is one of the best choices to block out a three storey building or window. It is perfect for windbreaks and noise barriers as well. It is used to make an excellent large screen. The shoots are edible, and the bamboo is nicknamed 'Sweet Shoot Bamboo' for its delicious flavor.

### **2.2.7. *Dendrocalamus brandisii***

**Local name:** Bulka (Bengal), Wanan(Manipur). *Dendrocalamus brandisii* also known as Velvet Leaf Bamboo, Teddy Bear Bamboo, or Sweet Dragon Bamboo.

**Synonyms:** *Bambusa brandisii* Munro, *Sinocalamus brandisii* (Munro) Keng f., *Arundarbor brandisii* (Munro) Kuntze.

**Description:** It is the largest tropical clumping bamboos in the world with height 19-33 m and diameter 13-20 cm.

**Culms:** The mature culm is smooth, ashy-gray to greenish-gray colored (Figure 15), loosely spaced and thornless. The culms are hollow with



internodes 30-38cm long and nodes slightly swollen with aerial roots in lower half of culm. Young shoots are dark-gray with a dark-brown blade.

**Culm sheaths:** of mature clumps are broad and long, usually 30-35cm broad to 40-60cm long, thick, leathery with pubescence on the back, rounded and depressed at the top. Ligules of sheath are 1-2 cm high, deeply lacerate with small and plaited auricles

**Branches:** Many clustered branches with one larger dominant branch.

**Leaves:** The arrow-shaped leaves are between 20-30 cm long and 2.5-5 cm broad, oblong to lanceolate in shape with a glabrous petiole and have minuscule short white hairs covering the leaf surface when young..

**Leaf sheaths:** Are straightly veined and pubescent. Base of the leaf blade may have a brief petiole like connection to sheath. The blades are lanceolate or oblong and pubescent.



Figure 15: *Dendrocalamus brandisii* growth performance at field (left, Anonymous, 2016) and greenhouse FRC (right).

**Flowering and Seeding:** Inflorescence is synflorescence and bractiferous mostly clustered at the nodes in globose formation. Spikelets are 1-1.5cm long, dense, 2.5-4cm between clusters and with glumaceous subtending bracts and with axillary buds at base of spikelet. Fertile spikelets sessile, comprising 2-4 fertile florets. Spikelets are ovate, 5-7.5mm long, laterally compressed. Glumes several, persistent with 1-2 empty glumes,

sometimes shorter than spikelet. Upper glume ovate, acuminate apex without keel. Lemma hairy above with puberulous surface and ciliate margins and acute apex. Palea 3-veined, 2-keeled ciliate. Flowers are also veined and ciliated. Anthers yellow, 6 in number, with apiculate tip. Filaments united in a tube with 1-2 plumose stigmas. Ovary ellipsoid, hairy, style short, stigmas ending in a thick, club-shaped or divergent, plumose stigmas. Seed is an ovoid caryopsis, 2.5-4mm, hairy above, tipped with the persistent style and crustaceous pericarp (Seethalakshmi and Mukteshkumar, 1998).

This species usually flowers sporadically as well as gregariously. Flowering cycle is reported to be 45-50 years. During the on-set of gregarious flowering the entire clump flowers profusely and dies within a period of 2-3 years after seed setting

**Distribution:** Origin: South east India. Grows in tropical-sub tropical climate. It is native in Southeast Asia. This bamboo grows on different soil types but prefer well-drained loamy soil. It grows best in wet evergreen tropical forests up to 1,300 m altitude.

**Silvicultural management:** Prefers soil with good moisture and high atmospheric humidity. As in most other bamboo species, *D. brandisii* also can be propagated through seeds as well as through macro and micropropagation methods. Seeds of this bamboo species are available for propagation through direct seeding. *D. brandisii* can be vegetatively propagated through rhizomatous cuttings, branch cuttings and also by culm cuttings.

**Uses:** It has fairly good physical and mechanical properties and is used locally in construction of ladders, fencing, building construction, small furniture, basket making boat masts, farm implements and in sericulture industry. It is also highly edible bamboo species in many parts of China. *D. brandisii*, being a fast growing species, is ideally suited for exploitation in farm forestry and agroforestry in humid tropics.

### 2.2.8. *Dendrocalamus latiflorus*

**Local name:** Taiwan Giant Bamboo

**Synonyms:** *Sinocalamus latiflorus* (Munro) McClure in Taiwan.

**Description:** *Dendrocalamus latiflorus* also called Taiwanese bamboo is a very large clumping species which grows to about 25 m (Figure 16).

**Culms:** thick walled (5-30 mm) woody culms between 14-25 m tall and 8-20 cm in diameter, which become thinner towards the top. Culm internodes are between 20 and 70 cm long and have a pale green color.

**Branches:** Many clustered branches with one larger dominant branch. Branches usually start occurring near the middle of the culm.

**Leaves:** Leaf-blades are lance-shaped and between 15-40 cm long and 25-75 mm wide.



Figure 16: Structure of a mature clump of *Dendrocalamus latiflorus* (left, Anonymous, 2016); seedling multiplication at Gurd Shola nursery of the Central Ethiopia EFRC (right)

**Flowering and fruiting:** *Dendrocalamus latiflorus* in general are usually monocarpic, living for many years before flowering, then flowering and seeding profusely for a period of 1-3 years before usually dying. Flowering of this species is rare in Taiwan; though sporadic flowering and fruiting is a normal occurrence in the Philippines, Indonesia and China.

**Distribution:** Asia-temperate (China and eastern Asia) and Asia-tropical (Indo-China). This bamboo species occurs in its native area under humid subtropical conditions, at elevations up to 1,000 m and can tolerate temperatures as low as -4°C. *Dendrocalamus latiflorus* prefers high rainfall and grows best in moist, sandy loam fertile soils. In the tropics it can be cultivated in lowlands as well as in the highlands, but heavy clay, gravel alkaline or acidic soils are not suitable for the production of edible shoots.

**Silvicultural management:** Seedling height, if propagated from seed, at times of planting in the field need to be 20 cm. A spacing of 4 m x 4 m is recommended while planting *D. latiflorus*. It is very drought tolerant and hardy once established. Young shoots that are used for food are harvested 7 - 25 days after emergence, when they are 35 - 60 cm tall. Harvesting may start in the 2<sup>nd</sup> year of growth of a clump in a bamboo shoot stand.

**Uses:** The poles can be used for building or arts and crafts. As it is so large, it also produces a good amount of shade for tables and chairs. Shoots are used for food both in raw and cooked forms; shoot are unusually free of any unpleasant taste, even when raw and considered to be delicious. They are also shredded and dried then used in Chinese-style snacks in Japan.

### **2.2.9. *Gigantochloa apus***

**Local name** (Indonesian names): Bambu Hitam (Indones), hitam = black; Bambus Wulung (Indones.); Pring Wulung (Javanese). In Indonesia this bamboo is called Bambu Tali ('Tali' means String) because it is an excellent resource to make strong strips with the suppleness of leather.

**Synonyms:** *Bambusa apus* Schult. f.; *Schizostachyum apus* (Schult. f.) Steud.; *Oxytenanthera apus* (Schult. f.) E. G. Camus; *Gigantochloa kurzii* Gamble.

**Description:** It is a dense strongly tufted tropical bamboo with erect drooping culms of 8-22 m height and 4-13 cm average diameter. Early growth performance of this species under Ethiopian condition is promising (Figure 17).

**Culms:** bright green or yellowish-green when young, and a wall thickness between 6-13 mm. Many clustered branches at the nodes with 1 larger dominant branch.

**Culm-sheath:** Blade triangular; deciduous; spreading, or reflexed; 3-10 cm long; 20-50 mm wide; pubescent; acuminate. Leaf-sheaths outer margin hairy.

**Leaves:** Leaves are lance-shaped and on average 10-15 cm long and between 1.5-2 cm broad.

**Leaf-sheath:** Auricles erect; 1-2 mm long. Ligule a ciliolate membrane; 1-2 mm long. Collar with external ligule. Leaf-blade base with a brief petiole-like connection to sheath; petiole 0.4-1.1 cm long. Leaf-blades lanceolate; 13-49 cm long; 20-90 mm wide.



Figure 17: *Gigantochloa apus* growth performances at Holetta (Central Ethiopia) at the age of 2 years (left) and seedling performance at Central Ethiopia EFRC (right).

**Flowering and fruiting:** *Gigantochloa apus* flowers. The stamens are colored lavender.

**Distribution:** It is found distributed in Thailand, China (Yunnan, introduced); Myanmar, Malaysia and Singapore (introduced), India. It is found in open sites or disturbed forests. It grows on lowlands along river banks or on hill slopes in moist evergreen forests up to 1500 m above sea level. It performs well in Ethiopia at altitude of 2400 m in Central Ethiopia, at Holetta (Figure 18).

**Silvicultural management:** Easy and fast-growing; grows well on moist sandy soil and clay soil.

**Uses:** Culms are very durable, used for construction (roofing, scaffolding, bridges) and for handicrafts and furniture and for making strips. It is the most economically important bamboo in Java, especially in the handicraft and furniture industry.

### ***2.2.10. Gigantochloa kuring Sumatra***

**Local name:** *Buluhkuringhitam* (Indones.)

**Synonyms:** *Bambusa. G. atrovioacea, G. atter, G. robusta, and G. pseudoarundnacea.*

**Description:** Rhizome is short, pachymorph bamboo with pink or purple and white stripes on green erect culms that are 20–25 cm in height and 2–7 cm in diameter (Figure 18).

**Culms:** woody; striped; internodes 30–50 cm long, terete with small lumen; mid culms green and yellow or purple; distally pruinose. Lateral branches dendroid.

**Culm-sheath:** Persistent 10.5–16 cm long; hispid; with appressed hairs; with black hairs; convex at apex; auriculate; with obtuse auricles; with 4 mm high auricles; setose on shoulders; shoulders with 7 mm long hairs. Culm-sheath ligule 2–3 mm high; dentate. Culm-sheath blade ovate; narrower than sheath; reflexed; 4.5–14.5 cm long; 15–35 mm wide; pubescent (sparsely).

**Leaf-sheath:** Leaf-sheath auricles falcate; 1–2 mm long. Ligule a ciliate membrane. Collar with external ligule. Leaf-blade base with a brief petiole-like connection to sheath. Leaf-blades lanceolate; 12–24 cm long; 16–22 mm wide. Leaf-blade surface glabrous.



Figure 18. *Gigantochloa kuring* Sumatra. Source: <http://www.bambooweb.info/>

**Flowering and fruiting:** Rarely flowers

**Distribution:** native to northern peninsula of Malaysia.

**Silvicultural management:** Requires consistently moist soil for its development. Propagation method is still not documented.

**Uses:** Used for clothing, house wares, accessories, furniture, poles, wind chimes, unusual bamboo tools. Suitable for growing in containers and makes an elegant container plant and a dense privacy screen.

### **2.2.11. *Gigantochloa atter* (Hassk.) Kurz ex Munro**

**Local name:** bambuater, Sweet Bamboo or Giant Atter (Indonesia)

**Synonym:** *Bambusa thouarsii* var. *atter* Hassk.

**Descriptions:** It grows up to height of 15 - 22 m and diameter 5 - 10 cm. culms are erect, upright. Its performance under Ethiopian condition is under evaluation (Figure 19).

**Culms:** is green with purple patches when young, which becomes purplish black when mature turns greyish purple when drying. Surface is smooth and glossy. Young shoots are purplish pink in color with green blades on culm sheaths. Branching occurs only at top. Internode length is 45-60cm. Culm internode wall is less than 1 cm thick.

**Culm sheaths:** Culm sheath is purplish pink with green blades in young plants turns dark brown when mature. It is triangular with a conical blade. Length of the sheath proper is 24-27cm in length and 40-45cm wide. Blade length is 4-7cm. Auricles absent. Upper surface of the sheath covered with black hairs. Lower surface of the sheath is not hairy. Sheaths fall off early.

**Leaves:** Foliage-leaf blades are large, 20 - 44 cm long, 3 - 9 cm wide and glabrous.



Figure 19: A clump of *Gigantochloa atter* (Photo Belayneh Azene, 2015)

**Flowering and Fruit:** It is not clear if seeds are known from *Gigantochloa atter*. It is stated in M. A. Rifai (1998) that flowers are known, but "caryopsis unknown", and that plants die after flowering. Whereas it is stated in Kew Grass Base that the fruit is a "caryopsis with adherent pericarp". It is a caryopsis with adherent pericarp.



**Distribution:** Indonesia: origin unknown, in Java only known in cultivation, known wild from other islands; usually planted in lowlands, but occurs up to 1,400 m altitude.

**Silvicultural management :** Easy-growing; in part shade to full sun, sandy loam to clay loam, normal moisture-retentive to moist with good drainage.  
**Uses:** Shoots for food; culms for construction, building material, furniture, musical instruments and handicraft (Rifai, M. A., 1998).

### **2.2.12. *Guadua angustifolia* Kunth**

**Local name:** Cebolla", "Macana", "Cotuda" or "Castilla", Iron bamboo, Phaikwadwa (Thai), Guadua Bamboo (English).

**Synonym:** *Bambus aguadua* Bonpl.

**Description:** Long-necked pachymorph bamboo forming loosely spaced culms of height 7 - 25 m and diameter 7 - 15 cm (Figure 20).

**Culms:** erect, upright; internodes green, thin-walled; nodes with thorns, with prominent sheath scar ring and initially with a dense band of appressed, cream-colored hairs below and above sheath scar; branches initially 1 - 3, central dominant, several on upper culm;

**Culm-sheaths:** pubescent; hairy throughout; with dark brown hairs; auricles absent; blade triangular and erect;

**Leaf-sheath:** oral hairs lacking. Ligule a ciliolate membrane. Collar with external ligule. Leaf-blade base with a brief petiole-like connection to sheath; petiole glabrous. Leaf-blades lanceolate, or oblong; 10–20 cm long; 6–12 mm wide. Leaf-blade venation without cross veins.



Figure 20: A mature stand of *Guadua angustifolia* (left, source: Anonymous, 2016); growth performance at Holetta testing site (right)

**Flowering and fruiting:** Inflorescence is borne on leafless or leafy twigs, 6-7cm long, linear, solitary and fasciculate. Spikelets curved with 14-14 florets with apical 4-6 florets more or less tabescent. Spikelets also absciss on maturity. Rachis segments are upto 3-4mm long, tomentose with 1-2 gemmiparous bracts which are triangular in shape.

Not much information is available on flowering cycle. In its native habitat, it is described as a non-gregarious flowering species. Fruit may best be described as globular caryopsis.

**Distribution:** Native from Venezuela to Peru, and widely cultivated in central and southern America. Thailand, introduced from the U.S.A. to central Thailand in 2011, in cultivation.

**Silvicultural management:** Can be propagated by seed, culm cuttings, branch cuttings as well as rhizome-based techniques (McClure, 1966). Branch cuttings treated with IBA2500ppm for 30 minutes resulted in > 80 % rooting within six-weeks in sand medium (Somasekhar *et al.*, 2004).

**Uses:** It is the most economically important bamboo in the humid, tropical Americas; primary source of building material for urban and rural dwellings, especially in Colombia and Ecuador, and raw material for numerous products.

### 2.2.13. *Phyllostachys pubescens*

**Local name:** *mousochiku* (Japanese), Moso bamboo (China), *tortoise-shell* bamboo

**Synonyms:** *Phyllostachys heterocycla pubescens*, *Phyllostachys edulis* Jaquith, *P. mitis*.

**Description:** *Phyllostachys pubescens* is a winter hardy giant timber bamboo originated in China (region Hainan) with culm height of 15 - 28 m and diameter of 7.62 - 12.7 cm (Figure 21).

**Culm:** young culms are of blue-green color, look as though they were covered with white powder.

**Leaves:** hang down like a waterfall.



Figure 21: A mature stand of *Phyllostachys pubescens* (left, source: Anonymous, 2016), seedling multiplication at Gurd Shola nursery, Central Ethiopia EFRC (right)

**Flowering and Fruiting:** Flowering cycles are not predictable, and occur only rarely, perhaps every 50 to 100 years. The old idea that bamboo dies in mass after flowering does not seem to hold with this species. Rather, an odd patch of culms will flower here and there.

**Distribution:** Moso bamboo can remain healthy in areas that have temperature as low as -20 C. Native to China and Taiwan and naturalized elsewhere.

**Silvicultural Management:** To grow this plant consideration of enough space to accommodate its rambling habit and the local environment likely to support its full growth potential is vital. This is not a plant for small yards and city lots. People may be tempted regardless, using underground barriers as a shield, but this plant is notorious for getting around such barriers. A more sensible means of containing a grove is by root pruning its outer edges every year to a depth of at least 60 cm, but one must be diligent in this task. Place to grow Moso is in a warm temperate climate with hot summers, and mild, yet cool to cold winters. Much of the southeastern USA is ideal for growing this plant provided it is planted in moist soils.

**Use:** Young shoots are edible. In Japan *P. pubescens* is called "noble bamboo".

#### **2.2.14. *Phyllostachys vivax* 'Aureocaulis'**

**Local names:** Alata, crookstem bamboo. Common name: Golden vivax, yellow groove bamboo

**Synonyms:** *Phyllostachys vivax* f. *aureocaulis*,

**Description:** It is an attractive, vigorous and tall clump-forming, evergreen bamboos with height of 8 to 11.8 m and diameter of 7-8 mm (Figure 22).

**Culms:** grooved on alternate sides between the nodes, and usually two leafy branches at each node, striped with green bearing; internodes up to 327 mm long. The part above the node commonly perceptibly larger in diameter than the part below the node and somewhat gibbous; nodes flaring rather abruptly at the sheath scar and thickened somewhat asymmetrical.

**Culm sheaths:** are entirely glabrous, farinose, densely maculate with dark spots, coarsely nervosa and thinly coriaceous when dry; *auricles* and *oral setae* lacking entirely in plants of mature stature (more or less well developed in small plants; *ligule* short, subglabrous, the apex strongly

arcuate, the margin ciliolae of subglabrous; *sheath blade* narrowly, triangular to sub linear, strongly crinkled, erect or reflexed, subglabrous on both surfaces.

**Branches:** are relatively short, glaucous, glabrous or several of the uppermost internodes pubescent at first then glabrescent, the branches and twigs 2-4 foliate.

**Leaf sheaths:** Glabrous, the margins ciliate; *auricles* sometimes slightly to moderately developed, ovate, all fragile and gradually disappearing; *oral setae* fragile, fugaceous, few and appressed in the upper sheaths, more numerous and radiate. Apex arcuate, often more or less concave in the middle. Petiole commonly puberulent at the base on the upper surface and often pilose toward the base of the leaf blade on the lower surface otherwise glabrous on both surfaces. Leaf blades up to 175 mm long and up to 25 mm broad, glabrous and shining above, the lower surface usually somewhat pilose along the midrib at the base, otherwise obscurely scabrous.

**Inflorescence:** unknown.



Figure 22: *Phyllostachys vivax* 'Aureocaulis' (Anonymous, 2016)

**Distribution:** *Phyllostachys aureosulcata* is a very common bamboo in the United States, Europe, Asia, and parts of Australia. In China it is cultivated and found in Beijing and the provinces Henan, Jiangsu and Zhejiang

**Silvicultural management:** Grow in fertile, humus-rich, moist but well-drained soil, in full sun or partial shade. Protect from cold drying winds. In a container grow in a loam-based compost and feed with a balanced liquid fertilizer on a monthly basis during the growing season. Should remain as a large thicket but may become invasive in warm, moist or favourable conditions. **Pruning** Remove weak, dead, damaged or spindly stems in spring and thin to show off stems to best effect. Cut out any flowering shoots promptly to discourage more from forming.

**Uses:** For ornamental purpose. Suggested planting locations and garden types Hedging & Screens Architectural Patio & Container Plants

### **2.2.15. *Phyllostachys aurea* Carrière ex Rivière & C. Rivière**

**Local name:** Phailueang chin (Thai). Golden Bamboo (English).

**Synonyms:** *Phyllostachys aurea* Carrière ex A. & C. Rivière f. *koi* Muroi, *Phyllostachys bambusoides* Siebold & Zuccarini var. *aurea* (Carrière ex Rivière & C. Rivière) Makino; *P. breviligula* W. T. Lin & Z. M. Wu; *P. formosana* Hayata; *P. reticulata* (Ruprecht) K. Koch var. *aurea* (Carrière ex Rivière & C. Rivière) Makino.

**Description:** Golden bamboo produces long, slender, and often hollow rhizomes (Figure 23). Common forms of *P. aurea* are easily identified by their characteristic compressed internodes in the lower part of the culms which have a tortoise shell-like appearance. This internodal compression result in shorter heights (10-12 m) and thicker culm diameters (5-7 cm) than many other *Phyllostachys* species.

**Culms:** will turn yellow in full or partial sun, and deepen into a gold-orange color as the plant matures, stiffly erect; internodes green, maturing to yellow, lower internodes often irregularly shortened, somewhat bulged,

and occasionally with oblique nodes; nodes of lower and middle culm distally inflated below sheath scar ring; branching and foliage tend to start lower to the ground than many other *Phyllostachys*, but some prefer to cut off lower branches to show off the interesting 'tortoise shell' lower part of the culms. Branches often occur in pairs and stems and branches are green when plants are young but turn golden yellow with age.

**Leaf:** Golden bamboo branches produce up to 6 leaves, which are often arranged in fan-like clusters. Leaf blades are narrow, grass-like and generally measure 2 to 6 inches (5-15 cm) long and up to 0.8 inch (2 cm) wide. Foliage leaf blades are light green.

**Flowers and fruiting:** Flowering is infrequent and unpredictable; flowers are grass like and not especially showy. Flowers have never been observed in much of the United States. When produced, flowers occur in spikelets up to 2 inches (2.5 cm) long with 8 to 12 flowers.



Figure 23: A clump of *Phyllostachys aurea* Carrière (Anonymous, 2016)

**Distribution:** Golden bamboo is not native to North America but is cultivated as far north as Vancouver, British Columbia, in the West and

Buffalo, New York, in the East. Escaped populations, however, are generally restricted to the southern United States from Texas to Florida and from Arkansas to North Carolina. Golden bamboo also occurs outside of cultivation on the islands of Hawaii and Oahu. These species of bamboo have been reported to be invasive in the mid-Atlantic and Southeast as well as some sites in the western and southwestern U.S. Infestations are commonly associated with new and very old residences from which they've escaped.

**Silvicultural management:** Rhizome growth by golden bamboo clones can result in the development of dense thickets and colonies. A single golden bamboo clump can produce up to 15 km of stems in its lifetime.. Golden bamboo "once established, is very aggressive in both its rate of growth as well as the sprouting of new stems". Spread is often "rapid" in all directions from the point of establishment. Golden bamboo seedling establishment is unlikely on burned sites, because golden bamboo rarely produces seed. However, sources indicate that golden bamboo spreads rapidly from rhizomes following disturbances. If established golden bamboo clones occur in or near burned areas, increased clone size or rhizome spread should be expected.

**Uses:**Mainly as an ornamental garden plant, and for landscaping. *P. Aurea*'s lush foliage make desirable for ornamental purposes and privacy hedges; and its characteristic 'knotty' compressed lower internodes render it desirable among collectors. This bamboo is great for making bamboo pipes

### **2.2.16. *Phyllostachys bambusoides***

**Local name:** Madake (Japanese), Giant Timber Bamboo, Japanese Timber Bamboo (English).

**Description:** *Phyllostachys bambusoides* is the strongest of all the temperate timber bamboos. It is a good bamboo for places that get snow, but do not get colder than 5°F, since it sheds snow better than most other large bamboos. It is also very upright, not leaning to the sun as some others do



(Figure 24). They are considered the second largest temperate bamboos, after Moso. It has a maximum height of 25 meters in its native habitat 15 cm in diameter.

**Culms:** Japanese Timber is an attractive running bamboo with dark green shiny culms. The culms are thick, straight, and erect. New culms usually grow rapidly at rates of up to 100 cm per day!

**Branches:** Are primarily found at the top of the plant when mature, although branches are found frequently at the lower nodes of a young plant.

**Leaves:** Leaves are dark green. The foliage acquires an orange tinge when grown with the correct amount of shade.



Figure 24: *Phyllostachys bambusoides*.

Source: <http://www.completebamboo.com>; Ned Jaquith (2003)

**Flowering and fruiting:** This species has the unique distinction of having the longest flowering interval of any other bamboo species at approximately 130 years. A mass flowering took place in the 1970's that was experienced primarily in the United States. Many well established *P. bambusoides* groves died off as a result of the flowering.

**Distribution:** Japanese Timber bamboo is widely grown in the U.S. and industrial and is quite common in Southeast Asia. A very common running bamboo throughout the world. Its origins are in China, but most commonly associated with Japan. It is also widely grown in the United

States, particularly Northern California, Oregon, and Washington state. Also found in Australia.

**Silvicultural management:** According to the website Complete Bamboo (2008) this species requires a rich loamy soil and plenty of moisture in the growing season plus a sheltered position. A very hardy plant, tolerating temperatures down to about -18°C, but it dislikes prolonged exposure to hard frosts.

Plants only flower at intervals of several years, viable seed is usually produced. When they do come into flower most of the plants energies are directed into producing seed and consequently the plant is severely weakened. They usually die after flowering, but if left alone they will sometimes recover though they will look very poorly for a few years. If fed with artificial NPK fertilizers at this time the plants are more likely to die (Complete bamboo, 2008).

**Uses:** The culm wood is ideal for construction. Culms are thick walled and straight. It is used frequently in Asia as scaffolding and also in the manufacture of furniture. The stems are durable and used as plant supports. It is the most widely grown bamboo in Japan for its useful culms. It is cultivated for its edible shoots in China. The shoots of Japanese Timber are somewhat bitter and rarely consumed raw. The shoots contain about 2.1% protein, 0.3% fat, 3.2% carbohydrate, 0.9% ash. It has been widely planted for ornament in the Mediterranean and is becoming naturalized there. The plant has an extensive root system and is used for erosion control.

### **2.2.17. *Phyllostachys iridescens***

**Local name:** Hong qiaozhu, Hong bujizhu (China). **Common name:** Cock Bamboo.

**Synonyms:** *Phyllostachys violascens*, *Phyllostachys parvifolia*, *Iridescens*  
*Bamboo*

**Description:** *Phyllostachys iridescens* is a large, timber bamboo, with excellent quality wood. It has an upright stature (Figure 25); some of the culms have attractive orange and burgundy stripes on them attaining height of 8-12 m and diameter up to 10 cm.

**Culms:** internodes green, becoming gray-green, 17–24 cm, initially white powdery, gradually showing yellow-green stripes in first two years; wall 6–7 mm thick; nodal ridge weakly elevated, as prominent as sheath scar.

**Culm sheaths:** Purple-red or pale purple-red, with purple-brown margins, densely purple-brown spotted, thinly white powdery, glabrous; auricles and oral setae absent; ligule purple-brown, arcuate, broad, with long, purple-red cilia, blade reflexed, green with red-yellow margins, linear, flat or weakly crinkled.

**Leaves:** It has 3 or 4 per ultimate branch; auricles absent; oral setae deciduous, purple; ligule moderately exserted, purple-red; blade 8–17 × 1.2–2.1 cm.



Figure 25: A clump of *Phyllostachys iridescens*. Sources: Noah Bell, 2009.

**Flowering and fruiting:** Branchlets spicate, (2.5–)5–6(–8.5) cm, scaly bracts 3–5; spathes 5–7, pubescent; oral setae 1–3, short; blade small.

Pseudospikelets 2 or 3(or 4) per spathe. Spikelets lanceolate, purple, 3–3.5 cm; florets 1–3, uppermost usually sterile. Glumes absent or 1, lanceolate; rachilla ending in a short, awnlike point, internodes pubescent; lemma 1.8–2.1 cm, glabrous, apex acuminate with an awnlike point; palea 1.5–1.8 cm, subglabrous or pilosulose at apex; keels conspicuous or inconspicuous; lodicules ovate-lanceolate, 2.5–3 mm. Anthers about 1 cm. Stigmas 3.

Plants only flower at intervals of many years. When they do come into flower most of the plants energies are directed into producing seed and consequently the plant is severely weakened. They sometimes die after flowering, but if left alone they will usually recover though they will look very poorly for a few years.

**Silvicultural management:** This species is hardy, resistant to cold climates. It can be propagated by using rhizome cutting or by clump division. Planting in the field requires a rich damp soil in a sheltered position with non-prolonged exposure to hard frosts. This species is notably resistant to honey fungus.

**Distribution: Origin:** China; the species is cultivated in Anhui, Jiangsu, Zhejiang provinces of China.

**Uses:** Culms are used as sunning pole, handle of farm implement, for constructing shed. This species is also grown for its delicious shoots.

### **2.2.18. *Schizostachyum jaculans***

**Local names:** Phaipo (Thai), Bulohnipis (Malay).

Misapplied name: *Schizostachyum blumei sensu Gamble*; Common Name: Blow pipe bamboo.

**Synonyms:** *Ochlandraridleyi* Gamble; *Schizostachyum ridleyi* (Gamble) Holttum.

**Descriptions:** Rhizome pachymorph, short, Culms erect with height 6 - 7 m and diameter 2 - 3.5 cm at the base.

**Culms:** longest internode usually 80 cm, sometimes 125 cm, young internodes with waxy powder below the node (Figure 26).

**Culm-sheaths:** 30 cm long, copiously brown-hairy on the back (Figure 26); blade green, soon reflexed, up to 25 x 1.8 cm; auricles about 1 mm high but 1.7 cm wide on each side, with pale bristles up to 1.2 cm; ligule 2 mm high with fringing hairs 3 mm tall.



Figure 26: Culm features of *Schizostachyum jaculan* (Anonymous, 2016)

**Flowering and fruiting:** Flowers and seeds unknown

**Distribution:** Thailand (South); Malaysia, in lowlands of the Malay Peninsula, widespread.

**Uses:** Culm internodes used for making blow-pipes.

## **Chapter III**

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### **3. Field Planting and Silvicultural Management of Introduced Bamboos**

As indicated in the Preface of this book, propagation techniques and nursery management of introduced bamboos is discussed in another book entitled "Propagation of Bamboos in Ethiopia" by Yigardu and Asabeneh (2016). Once seedlings and planting materials are prepared; the next steps are field planting and management of seedlings and the mature stand employing appropriate management techniques.

#### **3.1. Field planting**

Prior to planting bamboo in the field, a planting scheme which takes into consideration the size and growth habit of the species has to be determined. For plantation the recommended spacing for giant bamboos is 7x7m or 204 plants per hectare. This distance provides sufficient space for intercropping and allows greater ease of movement for maintenance and harvesting activities. A 5 x 5 m layout with 400 plants per hectare may however be used for riverbank and gully stabilization, or when intercropping of cash crops is not intended. For small sized bamboos, the distance between propagules (seedlings of rhizome-based techniques or offsets) can be 3 m X 3 m and for tall species like indigenous bamboos of Ethiopia, the spacing should not be less than 4 m x 4m (Maoyi, *et al.*, 2005).

Field planting can be done either by direct planting of offsets or using nursery-raised plants. The use of offsets for a large plantation is not practical, because of its high establishment cost and associated consequences on planting material sources. The preferred types of planting materials are bamboos raised in a nursery.

### **3.1.1. Selection and transporting of seedlings**

Plants that are used for planting in the field should be hardened at the nursery before transporting them to the planting site. Plants which are very young and delicate have a lower chance of survival in the field. It is important to select plants that have well developed roots and rhizomes. Such plants will be able to absorb nutrients from the soil and will be able to adapt to the harsher conditions of the field more easily than plants which are still developing roots. Plants at the nursery which have very long stems may be trimmed down to a height of 50 cm. It is however essential to ensure that the plants have sufficient foliage. Smaller plants with vigorous roots will require less energy for surviving in the field than taller plants. When transporting plants to the field, they should be handled carefully. The plants should be watered thoroughly prior to transport. They should be loaded and unloaded from the transport vehicle in such a way that no damage is caused to them. Upon arrival at the field site; the plants should be watered regularly up to the time that they are planted.

### **3.1.2. Planting site preparation and planting in the Field**

The following guidelines are suggested to aid the establishment of a productive plantation.

- When selecting the plantation site, check the quality of the soil. Bamboo can grow well on most soils, but deep porous fertile soil with high moisture content and a pH of 5.5 is preferable.
- Good soil drainage is very important. Verify that the land is not prone to flooding. Bamboo does not perform well on waterlogged soils. It is therefore preferable for the plantation to be situated on moderate slopes.
- Clear the land of all weeds and unwanted vegetation. Burning maybe necessary during the dry season.
- Carefully plan the layout of plantation so that the planting holes are placed at the specified distance and intervals.
- Plan the activities so that the plantation layout is completed at least two weeks before planting

- The planting holes should be positioned in a north-south orientation. This will provide an optimal distribution of sunlight to all the plants.
- Planting holes with a diameter of 1 m and a depth of 60 cm should be dug and evenly spaced out according to the plant spacing of 5 m X 5 m to 7 m x 7 m, depending on the size of the bamboo species.
- Planting should coincide with the start of the rainy season. If available, organic fertilizer or manure should be placed into each hole and mixed with the topsoil. The plants should be planted vertically in an erect position and the hole should be properly covered and mulched.

### **3.1.3. Direct planting of offset cuttings**

Direct planting of offset cuttings of bamboo in the plantation may be done in small plots or homestead farms. Planting should be conducted at the beginning of the rainy season. The selection and preparation of offset cuttings for direct planting follows the same procedure as that of planting stock for nursery-raised cuttings except that cuttings are directly planted in the field pits without potting. The procedure for direct planting is as follows:

- Transport the offset cuttings to the planting site.
- Loosen the soil in previously prepared planting pits/holes.
- Place the cuttings in the hole in a vertical position. The lowest node of the culm offset should be above the ground.
- Position the cutting at the center of the planting hole and fill up the pit with soil, ensuring that the culm stands firmly in place.
- Water the soil thoroughly and mulch around the planting hole.
- If necessary (and if financially possible), offsets should be protected against termite attack. The soil placed in the planting hole should be mixed with an anti-termite chemical. Marshal Susco controlled release - granules are suitable. The chemical has a persistent effect which lasts up to three years.



## **3.2. Plantation maintenance and harvesting**

Proper maintenance and protection of the plantation is highly important. This involves replanting, plant protection, weeding, general tending after field planting and sustainable harvesting of culms (bamboo stems).

### **3.2.1. Replanting**

Not all transplanted seedlings and offsets will survive the new environments. Plantations should therefore be visited regularly to check on the survival of plants and replace dead seedlings and offsets. Replanting should be done simultaneously with the first weeding schedule. This is done in the subsequent rain seasons when there is enough moisture until the second year.

### **3.2.2. Plant protection**

Bamboos are palatable to many animals, especially in dry grazing areas where goats are left loose. It is necessary to carry out protection against goats and antelopes. Where browsing come from large animals, some fencing may be necessary to allow establishment of the bamboo seedlings. Patrolling the area regularly can also protect the plantation from foraging animals.

### **3.2.3. Weeding and mulching**

Weeding should be regular or as necessary to avoid competition from weeds. Spot weeding rids the seedlings of competing weeds. This should be done at a radius of 60 cm around the seedlings after out planting. Mulching is a proven way of improving the growth of bamboo. In drier areas, with rainfall less than 1000 mm, mulching around plants greatly encourages growth through reduced evaporation of soil water. Mulching is achieved by uniformly spreading a layer of leaf litter or other organic material on the surface of the soil around the bamboo clump. Mulching is an effective way of preventing weed growth. It helps conserve soil moisture and contributes organic nutrients to the plant. Mulching is

absolutely necessary for the production of good quality bamboo shoots. The mulch protects young shoots from direct sunlight and keeps them moist, thus allowing them to grow to an optimal size without hardening and losing their edible quality.

#### **3.2.4. Soil maintenance**

During the first year, it is advisable to loosen the soil around the plant to improve soil aeration. Doing this about twice a year for each plant will enhance growth. Care should however be taken not to disturb the rhizome system of the plant.

#### **3.2.5. Clump management**

The proper maintenance of the clump not only improves productivity but also eases the job of the plantation worker. Clump management is partly a maintenance task and partly a result of harvesting. As a maintenance activity, it involves removing unwanted culms to prevent clump congestion. In congested bamboo stands, about 90% of new culms emerge in the outer borders of the clump, making the productivity of the central part of the clump deteriorating. New shoots and culms cause the clump to widen in diameter. Culms at the periphery of the clump are generally new or young, while older culms stand towards the interior of the clump. Understanding this is important for maintaining a bamboo clump such that its productivity and vigor is maximized.

In maintaining a bamboo clump of highly tufted sympodial introduced sympodial bamboos (*D. asper*, *D. hamiltonii*, *D. giganteus*, *D. membranaceous*, *Bambosa vulgaris* and others), it is necessary to extract the oldest culms in the interior of the clump by creating an opening in the clump and shaping the clump in the form of a horseshoe or "X shape". Monopodial bamboos have widely spaced (diffuse) culms, unless affected by soil compaction and mismanagement, hence mature culms can be selectively harvested in area basis rather than by clump basis.

Unless properly managed, bamboos tend to get congested resulting in deterioration both in quality and quantity. It is difficult to extract culms

from congested clumps. Preventing clump congestion is important so that harvesting can be done with greater ease. Thinning the clump is essential to provide space for the emergence of new shoots. It is sometimes necessary to sacrifice a few young culms in order to allow for better shoot production in the clump. Removal of old and rotting culms is also necessary to promote the healthy growth of shoots and new culms. Special attention should be placed on rotting stumps of culms that have been harvested. If rotting becomes apparent, it is advisable to dig around the stump and completely remove it. Likewise rotting culms should be extracted. Symptoms of disease or fungal infections should be noted and a plant pathologist should be advised for possible remedies and control measures.

### **3.2.6. Harvesting**

Harvesting of culms should be done either by applying harvesting designs or by selectively cutting mature culms. Systematic cutting of mature culms assures the continuous production of young shoots, which is an index of annual yield or increment. The implementation of plantation management strategies can help sustain the regenerative characteristics of bamboo and thereby provide an ensuring supply of raw material for industries. The bamboo plantation will be managed effectively if the exploitation is regulated on a sustainable yield basis.

Harvest culms only during the dry season. The starch content of bamboo is lower during periods of dryness. Lower starch content in the culms will make them less susceptible to attack by borers. Use very sharp tools. It is highly advisable to disinfect harvesting tools using bleach. This lowers the risk of infecting the plants. Do not cut young culms unless congestion in the clump prevents the cutting of mature culms. Cut each culm between 15 cm to 30 cm from the ground or just above the first node from the ground level. This is necessary so that water does not accumulate in the protruding internode. The accumulation of water may result in rotting and invites insects to lay their eggs. Never clear-cut an entire clump unless it has been verified to be seriously infected by a disease. Mulch each clump

after harvesting using branches and leaves of harvested culms. These should be neatly piled around the clump to provide organic material to enrich the soil around the clump.

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## 5. Glossary

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**acuminate:** having a long, slender, sharp point with concave sides, margins straight to convex

**acute:** sharp-pointed, margins straight to convex adaxial, adaxial surface: the sides towards the axis; the surface of a leaf that faces the stem during development, e. g. the upper side of the leaf. syn. ventral

**apex, apices:** the tip, the terminal end

**appressed:** closely and flatly pressed against the entire length of an organ or part

**arborescent:** of tree like habit; resembling a tree in growth or appearance

**attenuate:** with a long, slender taper, more gradual than acuminate; applied to base or apices of parts; gradually tapering

**auricle:** an ear-like lobe

**axial:** of or pertaining to an axis, especially main axis

**blight:** a plant disease where there is a sudden wilting or death of plant parts

**bristle:** a stiff strong trichome (hairs)

**caespitose:** Growing in tufts, like grass; describes the normal clump habit of bamboos with pachymorphrhizomes, except where the rhizome neck is elongated as in *A. alpina*.

**culm:** the aboveground stem of bamboos and any other grasses or sedges

**culm leaf:** consists of a sheath, blade, ligule and auricles

**culm sheath:** the sheath of the culm leaf, borne singly at each node of the culm proper, below the level at which the sheath of foliage leaves originate.

**cutting:** a vegetative portion removed (cut) from a plant for the purpose of propagation

**lanceolate:** much longer than broad; widened above the base and tapering towards the apex

**leaf sheath:** the basal portion of a leaf blade or petiole that more or less completely surrounds the stem



**ligule:** a membranous out growth on the upper surface of a grass leaf at the junction of the sheath and the blade. It may be presented by a ridge or by a line of hairs; an elongated flattened strap shaped structure

**linear:** long and narrow with sides parallel

**monopodial:** Having the form of a monopodium, "a stem of a single and continuous axis". The rhizome is one piece of the modified branch of a monopodial bamboo plant.

**oblique:** slanted; with unequal sides

**oblong:** much longer than broad with nearly parallel sides

**offset:** a short, lateral shoot or branch which develops from the main stem producing a means of vegetative propagation

**ovate:** egg-shaped in outline, with the axis widest below the middle

**pachymorph rhizome:** are rhizomes with bulb form and have short and compact internodes.

**rhizome:** an underground stem which comprises the rhizome proper, the rhizome neck, bears buds that grow in to culm or another rhizome, roots. The rhizome system constitutes the structural foundation of the plant.

**scabrous:** having a surface that is rough to touch, because of the presence of short stiff hairs

**sympodial:** having the form of a sympodium (syn=together; podos=foot); a term used to designate the branching habit of the type of rhizome described as pachymorph. In sympodial bamboo the rhizomes cannot run for a long distance, the culm base is the main part of the rhizome.

**sporadic:** widely dispersed or scattered; irregular in time, flowering at regular intervals

**striate:** marked with fine longitudinal parallel lines, as grooves or ridges

**truncate:** in clumps; clustered, caespitose

**tufted:** covered with dense, matted, woolly hairs

**undulate:** a margin wavy (up and down) in the vertical plane

**velvety:** with a matting of the soft hairs; the same as tomentose but dense so that the surface feels very smooth.

## 6. Annex

### Annex I: Priority species of bamboo

#### PRIORITY BAMBOOS

Twenty taxa of bamboos are accorded high priority for international action:

*Bambusa balcooa* Roxb.  
*B. bambos* (L.) Voss  
*B. blumeana* J A and J H Schultes  
*B. polymorpha* Munro  
*B. textilis* McClure  
*B. tulda* Roxb.  
*B. vulgaris* Schrad. ex Wendl  
*Cephalostachyum pergracile* Munro  
*Dendrocalamus asper* (Schultes f.) Backer ex Heyne  
*D. giganteus* Wallich ex Munro  
*D. latiflorus* Munro  
*D. strictus* (Roxb.) Nees  
*Gigantochloa apus* J A and J H Schultes  
*G. levis* (Blanco) Merrill  
*G. pseudoarundinacea* (Steud.) Widjaja  
*Guadua angustifolia* Kunth  
*Melocanna baccifera* (Roxb.) Kurz

*Ochlanrda* Thw. (spp.)  
*Phyllostachys pubescens*<sup>1</sup> Mazel ex H. de Leh (including *P. bambusoides* Sieb. and Zucc and *P. edulis* Makino)  
*Thyrsostachys siamensis* (Kurz) Gamble

#### ADDITIONAL SPECIES

A further 18 taxa are noted to be important:

*Arundinaria* spp.  
*Bambusa atra* Lindl.  
*B. heterostachya* (Munro) Holtum  
*B. nutans* Wall. ex Munro  
*B. oldhamii* Munro  
*B. pervariabilis* McClure  
*Lingnania chungii*<sup>2</sup> McClure  
*Dendrocalamus brandisii* (Munro) Kurz  
*D. hamiltonii* Nees  
*D. hookeri* Munro  
*D. membranaceus* Munro  
*Gigantochloa albociliata*<sup>3</sup> (Munro) Kurz  
*G. atroviolacea* Widjaja  
*G. balui* Wong  
*G. hasskarliana* (Kurz) Back. ex Heyne  
*Oxytenanthera* spp. Munro  
*Phyllostachys glauca* McClure  
*Schizostachyum* spp. Nees

Source: Raoet al., 1998



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