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The Potential of Bamboo as a Source of Renewable Energy in Northern Laos

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Introduction

Bamboo originates from Southeast Asia, where it is a natural component of the forest ecosystem. As many as 1500 bamboo species exist worldwide, most of which grow in Southeast Asia (Wong, 2004). Recently, bamboo has received increasing attention because of its easy propagation, vigorous regeneration, fast growth, high productivity and quick maturity. Bamboo is an efficient user of land, and produces more biomass per unit area than most tree species. Hence, the harvest of bamboo, grown in orchards, is possible after short cycles (Kumar, 2002). So far, bamboo seems to be an underestimated crop, as most bamboo currently used worldwide is cut from secondary forests. Only recently has bamboo been regarded as a crop worthwhile planting in orchards. The multifunctional range of bamboo uses has only lately received more attention. Experiences of other Asian countries have shown that it may prove beneficial for Laos to focus on bamboo as a valuable and sustainable natural resource. But ecologic and physiologic studies are urgently needed to estimate and evaluate bamboo production.

In the northern part of Laos, bamboo is known for its vigorous growth. Growth is distinctive in areas, where indigenous people still practice slash and burn to prepare the agricultural land (Uchimura 2002). In increasingly disturbed forest environments bamboo tends to suppress other trees and is even considered a weed in forestry practice (Wong, 1987). Consequently, bamboo distribution ranges from understorey in the secondary forest in its native form as a consequence of slashing and burning to its existence as a garden plant in an exotic form. In the traditional societies, bamboo utilization extends from a material for construction and handicraft to food and feed. Furthermore, bamboo products contribute to the income of many poor farmers.

A recent study attributed to bamboo a high potential as a biomass resource for bio-fuel or fibre, giving a rough overview on the potentials of three varieties of Japanese origin grown in the USA (Scurlock et al., 2000). Yet, there is lack of scientific information available about the area proposed in this study. Northern Laos undoubtedly belongs to the most under-researched regions in the world. Thus, an analysis of bamboo as a candidate for bio-energy with respect to its yield and fuel properties should be a basis for further scientific research in the northern region of Laos. This study serves as an initial basis for further research.

Materials and Methods

Laos is a small landlocked country in Southeast Asia bordering on Cambodia, China, Myanmar and Thailand. Bokeo, a small mountainous province in Laos, which belongs to the “Golden Triangle”, is located in the north-western part. In the main research areas, the ethnic minority

villages Viengphathana (47Q0679808/2215428), Phoutho (47Q0680140/2216539) and Houay Sang (47Q0686672/2216808), increasing population pressure forces indigenous people to resort to shorter rotation cycles of their traditional swidden cultivation practices (often called “slash and burn agriculture”). More land is thus being used for production processes with the result of a decrease in productivity. Seven bamboo species are abundant in the target areas and were analysed. Distribution and availability of bamboo species were investigated by sampling and conserving dominant culm-sheets, mapping methods and transect walks in the research area. Local importance and local usages were elicited by focus groups, consisting of indigenous people of different age and gender, in various villages. The use rating was done in cooperation with indigenous people and is an acceptance indicator. It shows the ranking of bamboo species which are mostly used. The use rating attempts to discuss the importance of species and supply pressures. Five to six culms of different species were harvested at ground level from wild and garden clumps. Branches and leaves were separated from the culm. Culms were cut lengthways and total length and internode distances were measured. Diameter and wall-thickness were measured after every node. The culm rating evaluates the species concerning their properties to produce biomass. Samples of nodes and internodes of more abundant species were taken for the analysis of fuel properties. Fresh weights of the samples were taken in the field immediately after the cutting process. Species were identified at the Chiang Mai University Herbarium, as well as compared with other local name translations. Literature revue was done to compare the different species found in northern Laos with other species known in Laos or bordering countries (Wang, Hong et al. 2005), (Tewari, 1990), (Ketphanh, 1995). Fuel properties were analyzed at the Faculty of Agriculture CMU. The moisture content was determined by oven method (ASTM: E1756-01). Ash content was analysed by muffle furnace (ASTM: E1755-01). Density was acquired by displacement method (ASAE: S269.4) and calorific value by oxygen bomb calorimetry (ASTM: E711-87). The fuel rating shows the potential of the species as a bio-fuel and could be a first indicator for their possible bio-fuel application field. The potential as a bio-fuel results in the sum of all rating parts of each specie.

Results and Discussion

Seven different species are common in the area of research. Differences in growth habit and in local use are listed in Table 1. *Gigantochloa nigrociliata* and *Thyrostachys siamensis* are exotic, thus their occurrence is relative scarce in the target area. The culm evaluation (Table 2) shows differences in culm diameters, culm wall thickness and internode length. There are several bamboo species for different fields of application by indigenous people in the area of research. Internode distances and culm-diameters are initial indicators for different uses. However, there is no clear distinction between bamboo species and their individual uses, ranging from two to six different usages per species. The culm evaluation and the following culm ratings are indicators for the biomass production of every culm. The analysis of fuel properties is listed in Table 3. Both focused on the native species *Bambusa pallida*, *Bambusa tulda*, *Dendrocalamus asper*, *Dendrocalamus membranaceus* and *Gigantochloa apus*. The moisture contents of the five different bamboo species ranged from 35% to 44 % which is higher than the figures found in the literature (e.g. Scurlock, 2000, El Bassam, 1998, Pugh, 1981). The ash contents (1.91%-4.99%) are similar to the findings of other authors (Scurlock, 2000, El Bassam, 1998 and Pugh, 1981) and comparable to grasses or straws. The heating values on dry basis (d.b.) ranged between 17.92 MJ/kg and 18.81 MJ/kg and are lower than those of many wood species but higher than comparable grasses (Scurlock, 1999, Nordin, 1994). As a whole (Table 4) *B. tulda, B. pallida* and *D. membranaceus* show the greatest potential as a bio-fuel. Summed to the fuel rating, the potential of the different bamboo species are described. *B. tulda, B. pallida and D. membranaceus* show the greatest potential as a bio-fuel. However, *D. membranaceus* competes with other utilisation purposes and the fuel properties are less good than *B. pallida, B. tulda* and

G. apus. Compared with other species, *B. tulda* and *B. pallida* have less use at the local level, but show great culm and fuel properties. Concerning the utilisation pressure in different application fields, *B. tulda* and *B. pallida* have the greatest potential.

Table 1: Classification of different bamboo species, origin, habitat and local uses

Species	Local Name	Origin	Habitat	Local Uses	Use Rating
Bambusa Pallida	Mai Hok	Native	Close to rivers, prefers shady flat areas	Construction, energy, feed, fence, food, handicraft	4
Bambusa Tulda	Mai Bong	Native	Dominating species, mixed forests, shady sloping areas	Energy, feed, fence, food	3
Dendrocalamus asper	Mai Hia	Native	Next to *G. apus* in mixed natural forests, shady sloping areas	Construction, energy, feed, fence, Food, handicraft	2
Dendrocalamus membranaceus	Mai Sang	Native	Mixed forest, flat to lightly sloping terrain, shady areas	Construction, energy, food, handicraft	1
Gigantochloa Apus	Mai Sod	Native	Next to *D. asper*, grows in flat and sloping sunny areas	Energy, handicraft	5
Gigantochloa nigrociliata	Mai Bo	Exotic	Imported species from old mountain village, occurrence rare	Handicraft	6
Thyrostachys siamensis	Mai Huak	Exotic	Imported species from old mountain village, occurrence rare	Construction, energy, feed, fence	7

Table 2: Culm evaluation of different bamboo species

Species	Height	Culm diameter	Internode length	Wall thickness	Culm Rating
	(m)	(cm)	(cm)	(cm)	
B. pallida	14-17	3-5	30-60	0.2-0.6	2
B. tulda	12-14	2-4	45-50	0.4-0.7	1
D. asper	14-16	4-7	Up to 100	0.4-0.7	4
D. membranaceus	12-18	3.6-4	30-50	0.3-0.6	3
G. apus	16-18	4-5	40-50	0.1-0.2	5

Table 3: Fuel properties and potential as a bio-fuel of different bamboo species

Species	Moisture content	Density	Ash content	Energy content	Fuel Rating
	(%)	(g/cm^3)	(in %)	($MJ/kg_{d.b}$)	
B. pallida	44	0.61	1.91	18.63	2
B. tulda	37	0.65	1.92	18.61	1
D. asper	37	0.77	4.23	17.92	5
D. membranaceus	43	0.62	4.99	18.81	4
G. apus	35	0.76	2.00	18.14	3

Table 4: Potential as a bio-fuel of different bamboo species

Specie	*B. pallida*	*B. tulda*	*D. asper*	*D. membranaceus*	*G. apus*
Use Rating	4	3	2	1	5
Culm Rating	2	1	4	3	5
Fuel Rating	2	1	5	4	3
Potential as a bio-fuel	**8**	**5**	**11**	**8**	**13**

Conclusion

Bamboo is abundant in Northern Laos, with more than seven different species in the target area. Two of them are scarce and seem to have little potential as a bio-fuel in this region. Those species that have a low utilisation rate, but a high culm and high fuel rate show great potential as a bamboo bio-fuel. This potential can be used, if bamboo is harvested in a systematic way and processed and sold on regional markets. The processing as charcoal could make handling and transport efficient enough to make it an economically interesting small scale industrial activity. As a CO_2 neutral source of energy it can replace fossil fuels. From the point of view of forest management the harvesting of the fast growing bamboo and the subsequent replacement with higher value trees may be a method to a sustainable increase in the value of the forest, both, in monetary terms and with respect to biodiversity.

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