Bamboo Forest – a potential source for bioenergy

B. ENGLER*, R. DIETENBERGER*, S. SCHÖNHERR** , Z. ZHONG°, G. BECKER*

* University of Freiburg, Institute of Forest Utilization and Work Science, Freiburg, Germany
** Eberswalde University of Applied Sciences, Eberswalde, Germany
° China National Bamboo Research Center, Hangzhou, PR China

Nanning，2011-11-23

- Brief introduction of bamboo forest
- Main study results
- Conclusions

中 国 竹 藤

## Bamboo and Rattan in China

Bamboo   Rattan

中国有竹子37属500余种，面积720万公顷，其中纯竹林420万公顷，最主要竹种毛竹300万公顷。天然分布于除新疆、内蒙古、吉林、黑龙江以外的27个省市自治区，集中分布于福建、湖南、浙江、江西、安徽、湖北、广东，以及西部的广西、贵州、四川、重庆、云南。

China has 37 genera and 500 species of bamboo with a total area of 7.2 million hectares, of which 4.2 million is pure bamboo stand and 3 million hectares is Moso bamboo forest. Bamboo is mainly found in Anhui, Fujian, Guangdong, Hubei, Hunan, Jiangxi and Zhejiang provinces in the east and Chongqing, Guangxi, Guizhou, Sichuan and Yunnan provinces in the west.

中国有棕榈藤3属25种6变种，分布于以海南为中心的东南部省份海南、广东、福建、江西、湖南、浙江和台湾，以及以云南为中心的西南部省份云南、广西、贵州和西藏。

In China there are 3 genera, 25 species and 6 varieties of rattan. In the southeast they are primarily distributed in Hainan province and also grow in Fujian, Guangdong, Hunan, Jiangxi, Taiwan and Zhejiang. In the southwest they are centered in Yunnan and extend into Guangxi, Guizhou and Tibet.

Fast-growing
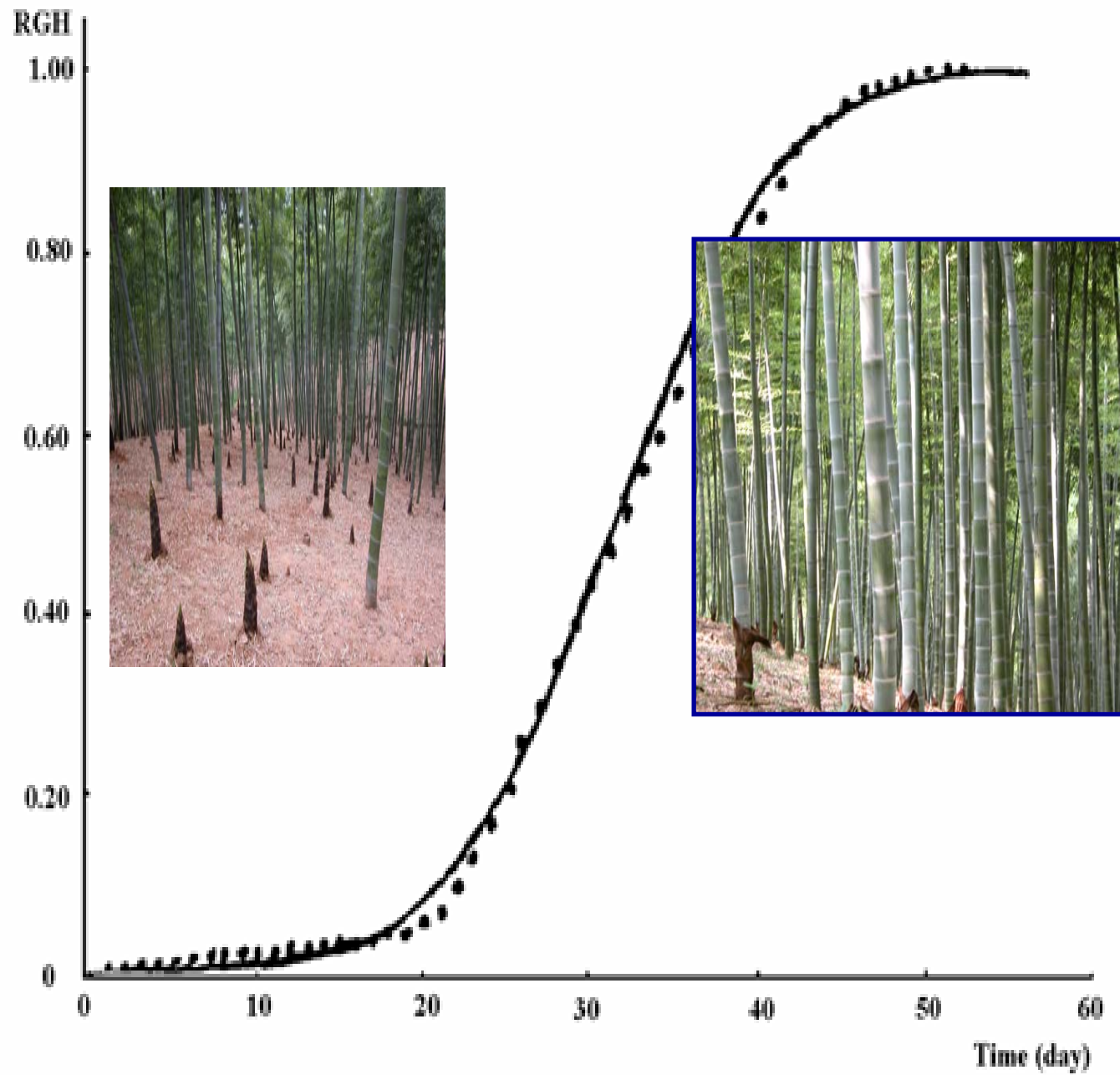
- Study question: can the fast growing species be used as a source for bioenergy with short-rotation.
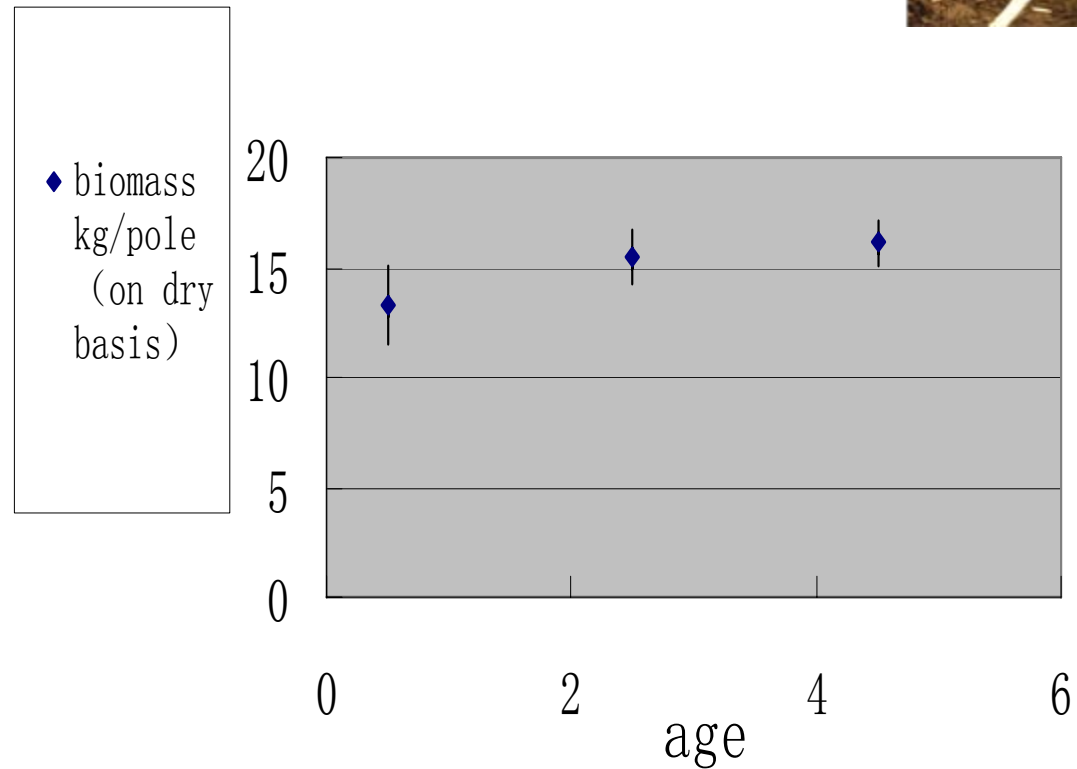
- Two bamboo species were selected for the study:
- Phyllostachys
- pubescens, called as Moso bamboo, mainly growing in the subtropical climate zone

- Bambusa emeiensis, mainly
- growing in the tropical region
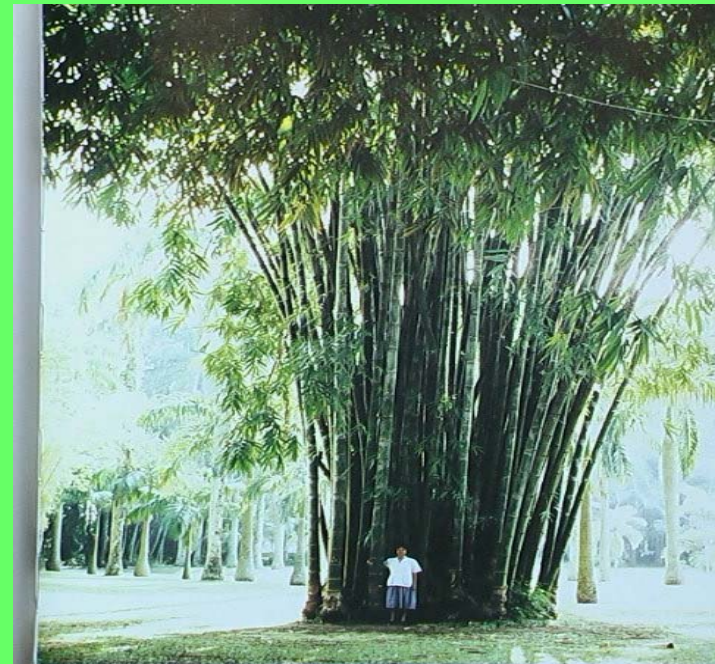
Study Results

- 1. Biomass and Moisture contents
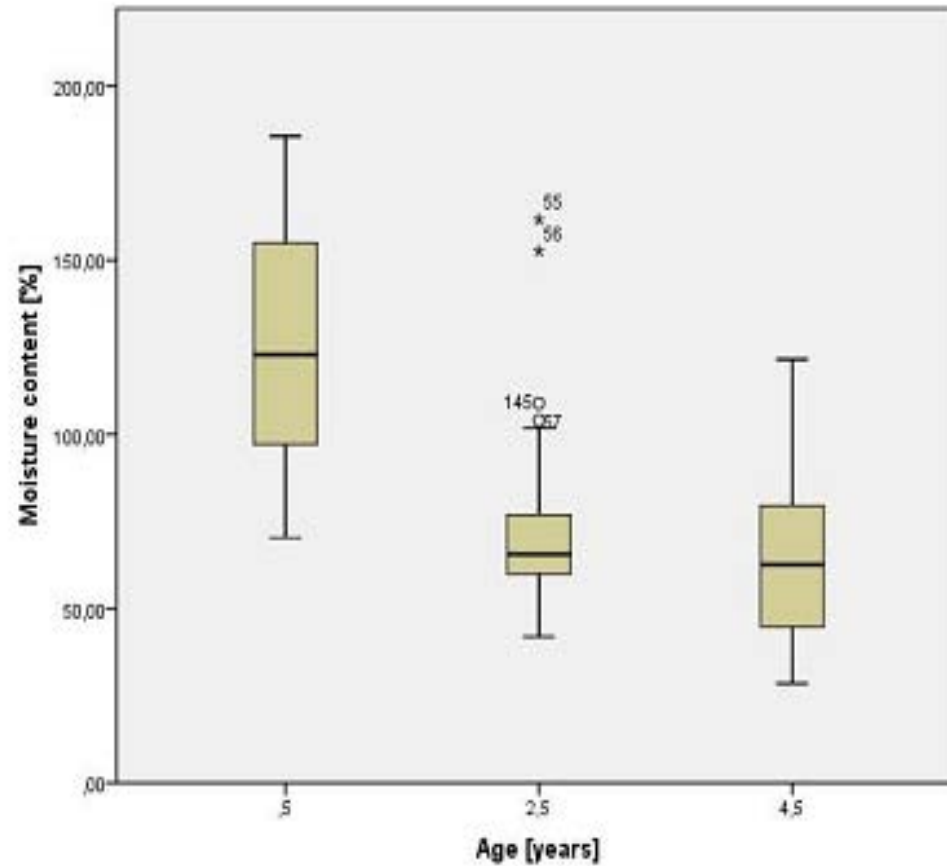
Biomass data for Moso bamboo with different age

Figure 2: Moisture content of *Phyllostachys pubescens* in dependency on the culms age
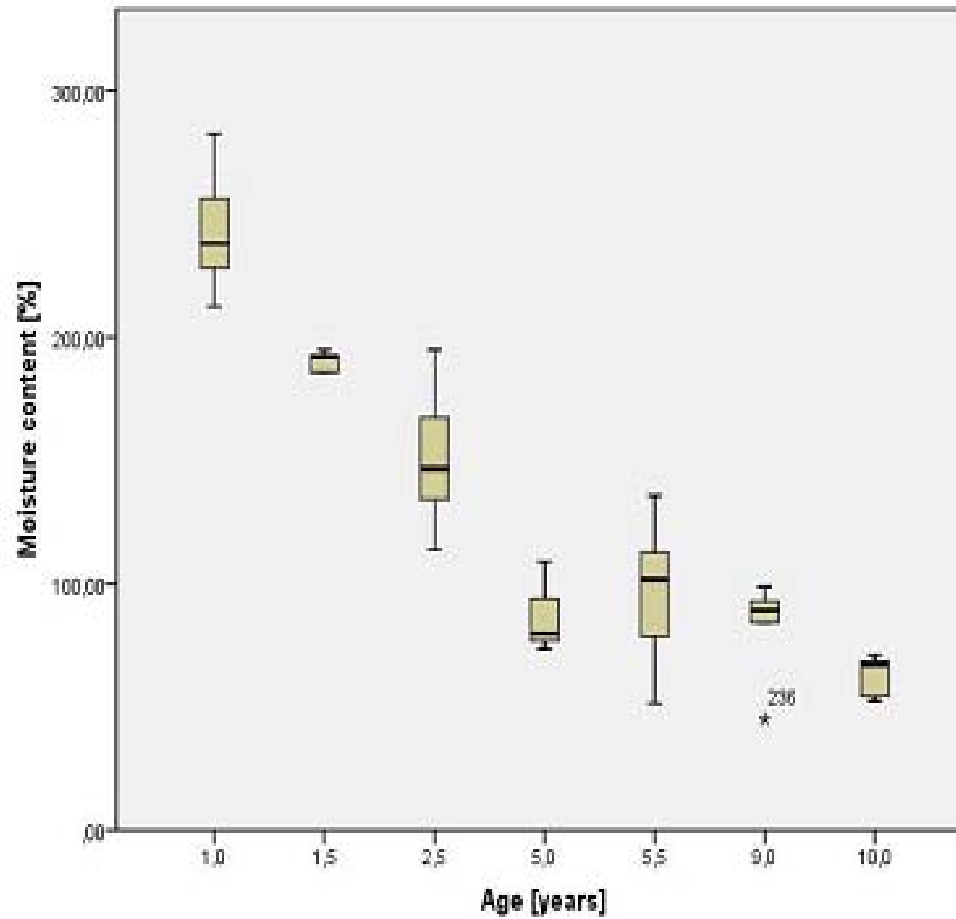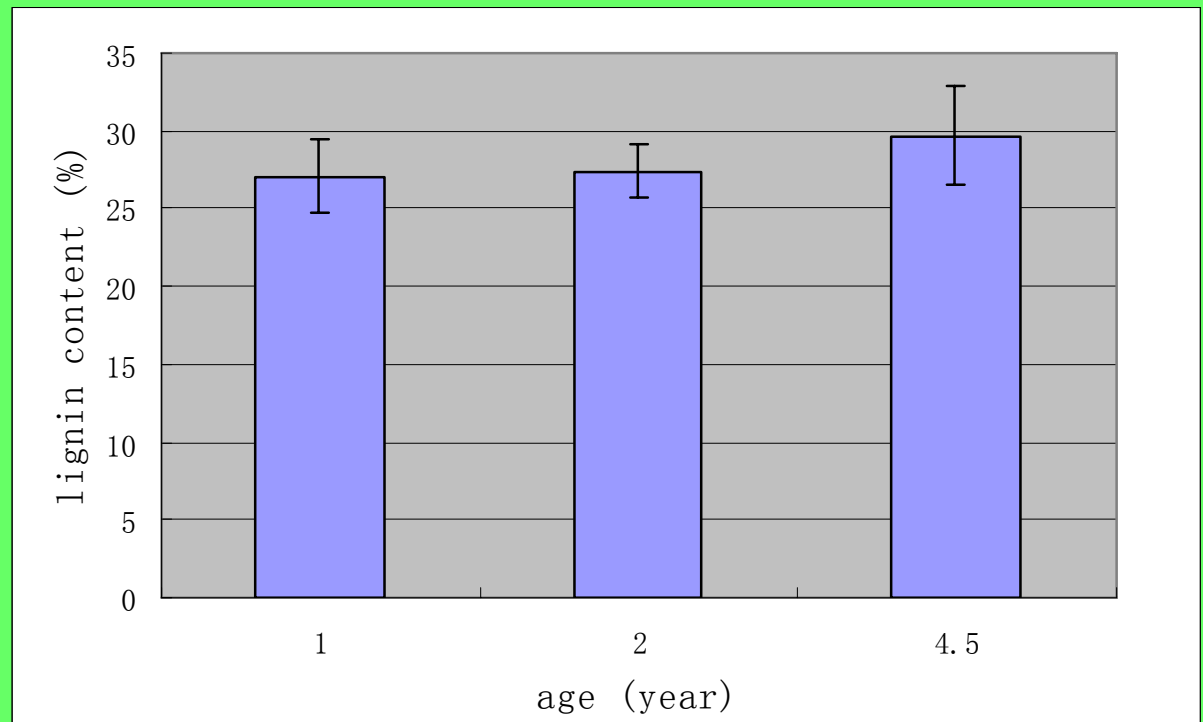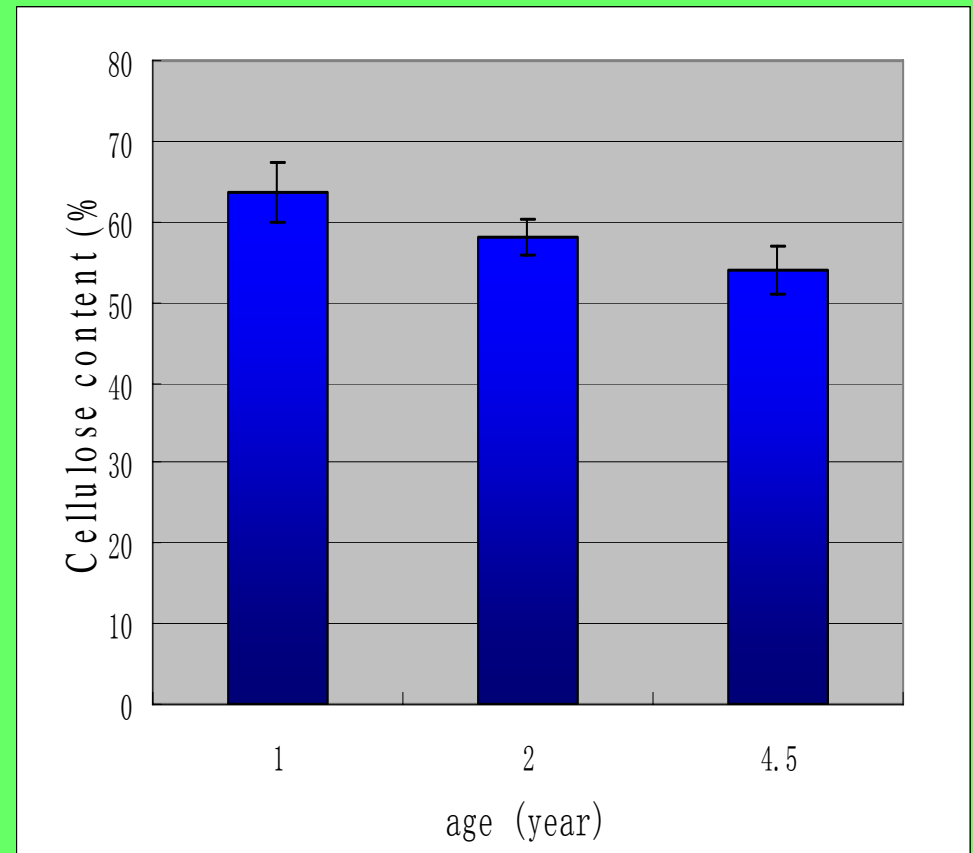
Figure 3: Average moisture content of *Bambusa emeiensis* against the culms age

2. Lignin and Cellulose contents

- **Lignin contents of bamboo culm slightly increased with the age**

- Cellulose contents significantly decreased with the age

3 calorific value and ash value

Table 4: Average combustion characteristics of *Phyllostachys pubescens* in dependency on the culms age

age [year]	position	moisture [%]	calorific value [J g⁻¹]	ash [%]	chloride [%]	n
0.5	bottom	165.4	19,344.8	2.69	0.07	18
	middle	124.3	19,307.4	2.22	0.08	18
	top	87.1	19,238.7	1.48	0.09	18
1.0	bottom		18,722.3	1.08	0.04	3
	middle		19,085.3	1.10	0.03	3
	top		19,201.3	0.95	0.13	3
2.0	bottom		19,200.3	2.26	0.03	3
	middle		19,427.7	1.26	0.02	3
	top		19,213.7	1.42	0.01	3
2.5	bottom	88.6	19,649.5	1.49	0.05	18
	middle	70.8	19,424.5	1.15	0.06	18
	top	56.1	19,616.6	0.85	0.07	18
3.0	bottom		19,097.0	2.49	0.05	3
	middle		19,282.3	3.35	0.02	3
	top		19,275.0	2.53	0.02	3
4.5	bottom	87.1	19,523.4	1.77	0.07	18
	middle	65.5	19,575.6	1.20	0.07	18
	top	41.0	19,760.5	0.89	0.11	18

age [year]	position	Bambusa emeiensis				n
		moisture [%]	calorific value [J g^{-1}]	ash [%]	chloride [%]	
1.0	bottom	233.3	18,366.7	2,70	0,09	4/6[1]
	middle	234.0	18,188.3	6,12	0,10	3/6
	top	279.5	18,070.3	3,56	0,11	2/3
1.5	middle	193.7	18,365.7	3,20	0,09	2/3
	top	185.9	18,206.3	4,07	0,10	2/3
2.5	bottom	149.2	18,533.0	3,00	0,09	6/9
	middle	154.4	18,432.0	3,60	0,11	6/9
	top	152.0	18,532.8	3,35	0,08	6/9
5.0	bottom	77.7	18,750.0	2,45	0,04	2/3
	middle	101.8	18,505.3	2,80	0,06	2/3
	top	77.6	18,380.0	2,46	0,04	2/3
5.5	bottom	98.7	18,628.5	2,58	0,07	4/6
	middle	106.8	18,513.2	2,63	0,07	4/6
	top	84.0	18,337.5	3,06	0,05	4/6
9.0	bottom	92.0	18,434.7	3,43	0,03	2/3
	middle	72.1	18,152.3	3,88	0,07	2/3
	top	86.1	17,602.0	6,90	0,06	2/3
10.0	bottom	69.2	18,330.7	3,53	0,04	2/3
	middle	68.4	17,475.3	8,02	0,03	2/3

4. Other analysis

	Phyllostachys pubescens (Moso)			Bambusa emeiensis				
	0.5	2.5	4.5	1	2	4	6	8
Ultimate Analysis (% dry matter)								
C	51.89	51.19	51.39	52.28	51.84	50.85	51.22	51.7
H	5.21	5.29	5.25	5.09	5.18	5.40	4.90	5.00
N	0.4	0.29	0.21	0.59	0.6	0.38	0.55	0.3
S	0.04	0.03	0.03	0.05	0.05	0.04	0.05	0.03
Cl	0.19	0.14	0.05	0.06	0.06	0.04	0.07	0.03

	Phyllostachys pubescens (Moso)			Bambusa emeiensis				
	0.5	2.5	4.5	1	2	4	6	8
Ash Elemental (% ash, 600°C)								
SiO_2	4.74	4.89	16.30	4.61	4.87	7.64	4.52	7.04
Al_2O_3	0.40	0.56	0.42	0.42	0.42	0.48	0.43	0.49
K_2O	44.20	50.00	33.60	44.50	42.80	30.50	46.20	42.70
P_2O_5	13.80	11.02	20.70	14.69	18.74	20.80	12.36	12.25
SO_3	2.94	2.51	2.32	2.13	2.27	3.18	4.17	2.93

3. Conclusions

- **Bamboo has a number of desirable fuel characteristics: low ash content (3%), low N(0.6%), low S(0.05) and Cl(0.08).**

- **The heating values were similar to the values of woody biomass (higher than 19 KJ g-1) and higher than most of the agricultural residues and grasses, furthermore, these values were not significantly changed with the age 0.5-4.5 for Moso bamboo, and for 1-10 years.**

3. Conclusions

- **The lignin and cellulose contents, which were slightly changed with the age, did not influence the calorific value, however, the water content of the bamboo biomass was the main concern for energy use. Therefore, from energetic point of view, the cutting rotations of 2-3 years and 4-5 years for the moso bamboo and Bambusa emeiensis , respectively , can be adopted.**

–Thanks for your attention