

*Bamboo and Rattan — Nature-based Solutions
for Sustainable Development*

*Promote the Action of Substituting Bamboo for Plastics
to Build a Clean and Beautiful World*



Celebration of INBAR's 25th Anniversary The Second Global Bamboo and Rattan Congress

7-8 November 2022
Beijing, China

ABSTRACTS

“Bamboo and Rattan - Nature-based Solutions for Sustainable Development”

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Abstracts

Hosts

National Forestry and Grassland Administration, China
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Thematic Area 1.

The Road to Carbon Neutrality





Designing biometric assessment for giant bamboo [*Dendrocalamus asper* (Schantz) Backer] growing in Bukidnon, northern Mindanao, Philippines

R. Aguinatan ^{1*}, M. Carandang ², R. Razal ², T. Villanueva ², D. Racelis ², J. Cerna ³

¹ Central Mindanao University, Maramag, Philippines
raguinsatan@cmu.edu.ph (*Corresponding Author)

² University of the Philippines, Los Baños, Philippines

³ Visayas State University, Baybay, Philippines

Abstract: Bamboo is the new emerging crop, a non-timber forest resource that received so much attention because of its environmental and economic importance. Unfortunately, most existing bamboo stands had no sufficient information with regards to their status and condition. Reliable estimates on the availability of the material are absent. Hence, this study was conceptualized. The primary aim is to develop an assessment method for the *Dendrocalamus asper* growing in Bukidnon. Specifically, it aimed to determine the variability and trends of the morphological characteristics and physical attributes of Giant bamboo culms as affected by site characteristics and harvesting practices; develop models to predict the average available stock of a given stand, and; create a user friendly spreadsheet that will automatically compute the quantity of the bamboo resource in a particular area or site. Results show that in assessing Giant bamboo plantation/stands, site characteristics and management scheme employed should be given considerations and must be factored in. Both clump size and culm characteristics are significantly affected by these factors. Steep slope and severe or over harvesting practices negatively affect the clump size, culm population, culm length, and culm diameter. Proximity to water body does not affect clump characteristics but to culms, it significantly affects. Riparian bamboos are longer, bigger, and have higher moisture content. DBH based power equation was identified as the best fitted model. A bamboo stock calculator (BSC) was devised, and a simple and doable assessment protocol was crafted.

Keywords: giant bamboo, assessment, harvesting practice, riparian

Nonstructural carbohydrate and water dynamics of Moso bamboo during its explosive growth period

Xue Li^{1,2,3†}, Chongyu Ye^{1,2,3†}, Dongming Fang⁴, Qiangfa Zeng^{1,2,3}, Yanjiang Cai^{1,3}, Huaqiang Du^{1,2,3}, Tingting Mei^{1,2,3*}, Guomo Zhou^{1,2,3}

¹ State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University,
Lin'an, China

² Key Laboratory of Carbon Cycling in Forest Ecosystems and Carbon Sequestration of
Zhejiang Province, Zhejiang A&F University, Lin'an, China

³ School of Environmental and Resources Science, Zhejiang A&F University,
Lin'an, China

⁴ Jiyang College of Zhejiang A&F University, Zhuji, China

ttmei@zafu.edu.cn (*Corresponding author)

† These authors have contributed equally to this work and share first authorship.

Abstract: Newly sprouted culm (culm_{new}) of Moso bamboo can complete its height growth within one or two months without growing any leaf. This explosive growth without enough leaf photosynthesis may rely heavily on external carbon input, such as carbon storage in the rhizomes or culms from the nearby mother culms (culm_{mother}). Therefore, this study monitored nonstructural carbohydrates in the culm_{mother} and water transfer between the culm_{new} and their attached culm_{mother} in a three-month experiment. Nine pairs of newly sprouted and attached culm_{mother} were categorized into three groups with three different treatments, i.e., 1) control without any treatment, 2) cutting off rhizomes between the culm_{new} and culm_{mother} (Treatment I), 3) removing all leaves of culm_{mother} based on the Treatment I (Treatment II). Before the culm_{new} leafing, there were significant transferred carbohydrates and newly photosynthesis carbohydrates from the culm_{mother}. In contrast, the carbon transfer became fewer after leafing. At the same time, the sap flow direction in the rhizomes indicated water flows from culm_{new} to culm_{mother} during the day and vice versa at night of the culm_{new} at the pre-leafing stage. These findings suggest that the explosive growth of the culm_{new} relies on both previous carbon storage and newly photosynthesized carbohydrates, and the carbon transfer may be coordinated with water transportation between the culms. Further study may pay attention to the potential support from the overall network of the bamboo stand or groves.

Keywords: explosive growth, Moso bamboo, carbon transfer, water transfer, sap flow

Physiological and biochemical characteristics of *Phyllostachys heteroclada* in response to waterlogging stress

Luo Huiying¹, Fan Shaohui^{1,2*}, Su Wenhui^{1,2}, Lin Xiaoyun¹, Jing Xiong^{1,2}, Long Yongmei¹, Sun Yutong¹, Chu Haoyu¹

¹ International Centre for Bamboo and Rattan, Beijing, China
luohuiying@icbr.ac.cn

fansh@icbr.ac.cn (*Corresponding Author)

² Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China

Abstract: Artificial vegetation restoration measure is important to maintain the normal structure and function of the ecosystem of riparianzone (FAN D et al., 2015), a fragile ecosystem (DING Y et al., 2018), which is important for biodiversity, ecological security, soil and water conservation, etc (Guo Z et al., 2007). To provide a theoretical basis for the selection of suitable tree species for revegetation in riparianzone, we investigated the physiological and biochemical responses of waterlogging-tolerant fast-growing bamboo species *Phyllostachys heteroclada* under flooding stress. The differences in photosynthetic gas exchange parameters, leaf resource utilization efficiency, antioxidant enzyme activity, endogenous hormones and non-structural carbohydrates were determined under three treatments: normally watering, total root flooding and half-flooding of *P. heteroclada*. It was found that under the flooding

treatment: (1) soluble protein content increased with increasing stress time and showed a positive correlation with the degree of stress; (2) leaf water resource utilization, intercellular CO₂ concentration and total photosynthetic pigments of materials showed a decreasing and then increasing trend with increasing stress time, and the ratio of chlorophyll a to chlorophyll b increased from 3:1 to 2:1; (3) antioxidant enzyme activity increased with increasing waterlogging time. The study showed that the short-term moderate waterlogging stress showed a boosting effect on photosynthesis, and then the photosynthetic parameters gradually decreased to a stable level. *P. heteroclada* maintain the normal operation of photosynthetic system and cell membrane system through a series of physiological and biochemical responses, so that *P. heteroclada* has a good resistance to waterlogging and suitable for ecological restoration in riparianzone.

Keywords: *waterlogging stress, P. heteroclada, riparianzone, photosynthetic parameters, stress resistance physiology*

Evaluation of bamboo forest ecosystem services in feicheng city

Li Yi

*Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, International Centre for Bamboo and Rattan, Beijing, China
3496864562@qq.com (Corresponding Author)*

Abstract: Based on the data of the Third National Land Resources Survey of Feicheng City, using ecosystem value assessment methods such as shadow engineering, market value and opportunity cost method, the ecosystem service value of bamboo forest in Feicheng City was evaluated for water conservation, carbon fixation and oxygen release, soil conservation, nutrient accumulation and biodiversity conservation. The results show that the total ecosystem service value of bamboo forest in Feicheng Was 10,710,900 yuan, and the service value per unit area was 75,300 yuan. Among them, water conservation and carbon fixation and oxygen release contributed the highest value, totally accounting for 72.28% of the total value of the ecosystem service, which were the main service provided by the bamboo ecosystem in Feicheng City. The evaluation results of the study provide reference for the Feicheng ecological restoration project construction in abandoned mining areas and formulating the ecological compensation policies and the subsequent ecological benefits evaluation of bamboo forest.

Keywords: *bamboo forest, ecosystem service value, value assessment method, Feicheng city*

CO₂ capture by a novel porous bamboo carbon material loaded with organic amines

Wenkai Zhu¹, Song Li¹, Yang Zhang^{2*}

¹ College of Chemistry and Materials Engineering, Zhejiang A&F University, Hangzhou, China

² Jiangsu Co-Innovation Center of Efficient Processing and Utilization of Forest Resources, College of Materials Science and Engineering, Nanjing Forestry University, Nanjing, China
Yangzhang31@163.com (*Corresponding Author)

Abstract: The proposal of carbon peaking and carbon neutralization strategies has drawn extensive attention to the research on efficient and sustainable CO₂ capture materials. Bamboo has a high carbon sequestration ability, and it is of practical significance to develop new materials derived from bamboo charcoal and apply it to the field of CO₂ capture. In this work, we used the original bamboo as the basic material to obtain a new type of porous bamboo charcoal after carbonization. And, adopted the impregnation method to load organic amines into it to obtain a new type of bamboo charcoal material with excellent CO₂ capture performance. Relevant characterizations show that NH₂ and C-N from organic amine incorporated onto bamboo charcoal. Meanwhile, the presence of N1s peak in aminated bamboo charcoal, meaning that the hydroxyl groups reacted with the NH₂ of organic amine. Furthermore, the organic amine-loaded bamboo charcoal had abundant porous structure and large specific surface area, which suggests that the material had excellent adsorption performance. The CO₂ adsorption capacity of novel bamboo carbon material reached 2.65 mmol/g at 25 °C under pure dry CO₂ atmosphere. Moreover, it had excellent CO₂ selective adsorption performance, and the separation coefficient can reach 30. Significantly, this work provides a new strategy to construct novel bamboo derived materials as abundant porous structure for CO₂ capture.

Keywords: bamboo charcoal, amine functional, porous structure, CO₂ capture

The miRNA-mRNA network regulates tissue differentiation in Moso bamboo shoots

Y. Li^{1*}, D.Q. Zhang², S.Q. Zhang¹, Y.F. Lou³, X.M. An², Z.H. Jiang¹, Z.M. Gao¹

¹ International Centre for Bamboo and Rattan, Beijing, China
liying@icbr.ac.cn (*Corresponding Author)

² Beijing Forestry University, Beijing, China

³ Jiangxi Academy of Forestry, Jiangxi, China

Abstract: The differentiation and development of various tissues make the underground shoot thickening continuously, and complete the embryonic form of all tissues and organs of the above-ground culm before being unearthed. Primary thickening of bamboo shoots determines bamboo yield and wood property. However, little is known about the regulatory networks involved in this process. This study identified a total of 58,652 genes and 150 miRNAs via

transcriptome and small RNA sequencing using the underground thickening shoot samples of wild-type (WT) Moso bamboo (*Phyllostachys edulis*) and a thick wall (TW) variant (*P. edulis* “Pachyloen”) at five developmental stages (WTS1/TWS1-WTS5/TWS5). A total of 14,029 (65.17%) differentially expressed genes and 68 (45.33%) differentially expressed miRNAs were identified from the WT, TW, and WTTW groups. Among the phytohormones, zeatin showed more remarkable changes in concentrations than indole-3-acetic acid, gibberellic acid, and abscisic acid throughout the five stages in the WT and the TW groups. Additionally, we assessed the differences in profiles and levels of genes, miRNA, and key phytohormones between the WT and TW bamboo across five developmental stages and delineated the connections among these factors in the thickening bamboo shoots. Moreover, localization verification indicates that miR166 is associated with xylem patterning and that there might be a relationship between the development of the underground shoot, root and internode of the seedling. Thus, tissue differentiation is a complex process regulated by miRNA–gene–phytohormone networks, and the miRNAome and transcriptome dynamics regulate phenotypic plasticity. These findings provide insights into the molecular mechanisms underlying wood formation and properties and propose targets for bamboo breeding.

Keywords: *miRNA, tissue differentiation, transcription factor, phytohormone, bamboo shoot*

Carbohydrate metabolism and its regulation are the main factors affecting the quality of postharvest bamboo shoots

Z. Li^{1,2}, X.R. Xu³, K.B Yang^{1,2}, C.L. Zhu^{1,2}, Y. Liu^{1,2}, Z.M. Gao^{1,2*}

¹ *Institute of Gene Science and Industrialization for Bamboo and Rattan Resources, International Centre for Bamboo and Rattan, Beijing, China
gaozhimin@icbr.ac.cn (*Corresponding Author)*

² *Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China*

³ *Zhejiang Academy of Forestry, Hangzhou, China*

Abstract: Bamboo shoot is one of the popular nutritious vegetables in China. However, the edible quality of fresh bamboo shoots easy to deteriorative after harvest. Although carbohydrate metabolism is an important factor affecting the quality of vegetables, it remains largely unknown for the postharvest bamboo shoots. Here, morphological, physiological, transcriptomic and microRNA sequencing analyses were conducted to investigate the characteristics of postharvest moso bamboo (*Phyllostachys edulis*) shoots. Rapid decreases in content of soluble sugars, structural polysaccharides and hydrolyzed tannins, and increases in content of lignin and condensed tannins were observed in the shoots, which led to edible quality decline. Transcriptomic and microRNA (miRNA) sequencing analyses showed that the identified differentially expressed genes (DEGs) and differentially expressed miRNAs (DEMs) were mainly enriched in structural polysaccharide metabolism, starch and sucrose metabolism and glycolysis pathways. The expression trends of these DEGs were opposite to those of DEMs, which were consistent with the content changes of carbohydrates. A co-expression network of carbohydrate metabolism was constructed, containing 15 transcription factors, 78

structure genes and 30 miRNAs, which was verified by qPCR and Y1H assay. Furthermore, one hub gene encoding glycosyltransferase was validated to be involved in xylan biosynthesis in *Arabidopsis*. These results are of great significance for revealing the carbohydrate metabolism mechanisms of postharvest bamboo shoots and provide a potential candidate gene for molecular breeding related to xylan in the future. Furthermore, this basic research has important reference value for the reasonable storage and transportation of bamboo shoots.

Keywords: *Phyllostachys edulis* shoot, postharvest physiology, carbohydrate metabolism, co-expression network, xylan biosynthesis

A bamboo violaxanthin de-epoxidase gene, *PeVDE*, confers photoprotection ability under high light

H.Y. Sun^{1,2}, Y.F. Lou³, C.L. Zhu^{1,2}, K.B. Yang^{1,2}, X.P. Li^{1,2}, Z.M. Gao^{1,2*}

¹ Institute of Gene Science and Industrialization for Bamboo and Rattan Resources,
International Centre for Bamboo and Rattan, Beijing, China
gaozhimin@icbr.ac.cn (*Corresponding Author)

² Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo
and Rattan Science and Technology, Beijing, China

³ Jiangxi Provincial Key Laboratory of Plant Biotechnology, Jiangxi Academy of Forestry,
Nanchang, China

Abstract: Plants employ an array of photoprotection mechanisms to alleviate the harmful effects of high light intensity. The violaxanthin cycle, involves violaxanthin de-epoxidase (VDE) and zeaxanthin epoxidase, is one of the most rapid and efficient mechanisms protecting plants under high light intensity. Woody bamboo is a class of economically and ecologically important evergreen grass species. However, the function of VDE in bamboo has not yet been elucidated. In this study, we found that high light intensity increased non-photochemical quenching (NPQ) and stimulated the de-epoxidation of violaxanthin cycle components in moso bamboo (*Phyllostachys edulis*), whereas samples treated with the VDE inhibitor (dithiothreitol) exhibited lower NPQ capacity. Further analysis showed that *in situ* mutant of the *PeVDE* gene in bamboo leaves by gene-editing could decrease the values of NPQ under high light, suggesting that violaxanthin cycle plays an important role in the photoprotection of bamboo. Overexpression of *PeVDE* under the control of the *CaMV 35S* promoter in *Arabidopsis* mutant *npq1* mutant could rescue its NPQ, indicating that *PeVDE* functions in dissipating the excess absorbed light energy as thermal energy in bamboo. Moreover, compared with wild-type (Col-0) plants, the transgenic plants overexpressing *PeVDE* displayed enhanced photoprotection ability, higher NPQ capacity, slower decline in the maximum quantum yield of photosystem II (F_v/F_m) under high light intensity, and faster recovery under optimal conditions. These results suggest that *PeVDE* positively regulates the response to high light intensity in bamboo plants growing in the natural environment, which could improve their photoprotection ability through the violaxanthin cycle and NPQ.

Keywords: *Phyllostachys edulis*, violaxanthin cycle, photoprotection, NPQ, *PeVDE*

Comprehensive analyses and development of simple sequence repeats (SSRs) based on the whole-genome sequences of five bamboo species

Y. Liu^{1,2}, X.Y. Xiao^{1,2}, G.Z. Li^{1,2}, C.L. Zhu^{1,2}, K.B. Yang^{1,2}, X.H. Feng³, Y.F. Lou⁴,
Z.M. Gao^{1,2*}

¹ Institute of Gene Science and Industrialization for Bamboo and Rattan Resources,
International Centre for Bamboo and Rattan, Beijing, China
gaozhimin@icbr.ac.cn (*Corresponding Author)

² Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo
and Rattan Science and Technology, Beijing, China

³ Beijing Black Bamboo Park, Beijing, China.

⁴ Jiangxi Academy of Forestry, Nanchang, China.

Abstract: Simple sequence repeats (SSRs) are one of the most important molecular markers, which are widespread in plants. Bamboos are important forest resources worldwide. Here, the comprehensive identification and comparative analysis of SSRs were performed in three woody and two herbaceous bamboo species. Altogether 567,175 perfect SSRs and 71,141 compound SSRs were identified from 5,737.8 Mb genome sequences of five bamboo species. Out of ten types of SSR, dinucleotide SSRs were the most predominant type, with an average of ~ 50,152.2 per species. Most SSRs were located in intergenic regions, while those located in genic regions were relatively less. Further analysis showed the number of genes containing SSRs ranged from 6,284 to 18,606 in five bamboo species. Moreover, the results of annotation distribution indicated that terms with P450, peroxidase and ATP-binding cassette transporter related to lignin biosynthesis might play important roles in woody and herbaceous bamboos under the mediation of SSRs. Furthermore, the peroxidase gene family consisted of a large number of genes containing SSRs was selected for the evolutionary relationship analysis and SSR markers development. The results demonstrated all the orthologous gene pairs and most paralogous gene pairs of peroxidase genes in five bamboo species underwent purified selection during evolution. Besides, 15 SSR markers derived from peroxidase family genes of *Phyllostachys edulis* were identified as polymorphic in 34 accessions belonging to seven genera in Bambusoideae. These results provided a comprehensive insight of SSR markers into bamboo genomes, which would facilitate bamboo research related to comparative genomics, evolution and marker-assisted selection.

Keywords: bamboo, SSR, whole-genome identification, comparative analyses, molecular markers

Nitrogen fertilization in bamboo forest accelerates the shoot growth and alters the lignification process in shoots

K.B. Yang^{1,2}, C.L. Zhu^{1,2}, J.B. Zhang³, Z.Y. Li^{1,2}, Y. Liu^{1,2}, X.Z. Song³, Z.M. Gao^{1,2*}

¹ Institute of Gene Science and Industrialization for Bamboo and Rattan Resources,
International Centre for Bamboo and Rattan, Beijing, China

*gaozhimin@icbr.ac.cn (*Corresponding Author)*

² *Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China*

³ *Zhejiang A&F University, Hangzhou, China*

Abstract: As one of the key nutrients, nitrogen is a major driving force for plant growth and development, and ultimately contributes to biomass improvement. However, little is known about the common genetic basis of bamboo growth with nitrogen fertilization. Here, the physiological-biochemical characteristics showed that nitrogen fertilization in moso bamboo (*Phyllostachys edulis*) forest obviously affected the activities of multiple enzymes in shoots, which led to changes in metabolite content. The lignin content was significantly inhibited in shoots during the early stages of fast growth, while the content was subsequently promoted at the late stage, which resulted in a similar lignin content between nitrogen fertilization and control in 8.0 m shoots. Based on transcriptome data, we generated a global map of changes in the transcriptomic dynamics during fast growth, which showed that upregulated differentially expressed genes (DEGs) in 1.0 and 4.0 m shoots were significantly enriched in growth-related GO terms, while upregulated DEGs in 8.0 m shoots were enriched in lignin biosynthesis-related GO terms. Two regulatory networks were constructed: two key structural genes (KSGs) and 118 transcription factors (TFs) involved in nitrogen metabolism and 17 KSGs and 102 TFs involved in lignin biosynthesis using WGCNA, which validated by yeast one-hybrid assays. Overall, nitrogen fertilization differentially affected moso bamboo shoots at different fast growth stages through the expression of genes involved in multiple metabolic pathways, indicating that moso bamboo has plasticity to environmental factors. These results lay a foundation for the genetic improvement and sustainable management of bamboo forests via nitrogen fertilization.

Keywords: *Phyllostachys edulis, nitrogen fertilization, growth performance, nitrogen metabolism, lignification*

Comparative transcriptome analysis uncovers the regulatory roles of MicroRNAs involved in variation of culm colours in bamboo

C.L. Zhu^{1,2}, Y.F. Lou^{1,2,3}, K.B. Yang^{1,2}, Y. Liu^{1,2}, X.Y. Xiao^{1,2}, Z.Y. Li^{1,2}, D. Guo^{1,2}, H.Y. Sun^{1,2}, Z.M. Gao^{1,2}*

¹ *Institute of Gene Science and Industrialization for Bamboo and Rattan Resources, International Centre for Bamboo and Rattan, Beijing, China*

*gaozhimin@icbr.ac.cn (*Corresponding Author)*

² *Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China*

³ *Jiangxi Academy of Forestry, Nanchang, China*

Abstract: Culm colour variation is an interesting phenomenon that contributes to the breeding of new varieties of ornamental plants during domestication. De-domesticated variation is considered ideal for identifying and interpreting the molecular mechanisms of plant mutations.

However, the variation in culm colour of bamboo remains unknown. In the present study, yellow and green culms were generated from the same rhizome of *Phyllostachys vivax* cv. Aureocaulis (*P. vivax*) was used to elucidate the molecular mechanism of culm colour formation. Phenotypic and physiological data showed that the DBH, and IWT were larger, ID of internodes was longer, NPR and SC were higher in green culms compared with yellow culms. The contents of chlorophyll a, chlorophyll b, flavonoid carotenoid and soluble sugar were all increased, while the contents of anthocyanin were decreased in green culms. High-throughput sequencing analysis showed 295 differentially expressed genes (DEGs) and 22 differentially expressed miRNAs (DEMs) in two different coloured bamboo culms. There were 103 DEM-DEG interaction pairs, of which a representative ‘miRNA-mRNA’ regulatory module involved in photosynthesis and pigment metabolism was formed by 14 DEM-DEG pairs. The interaction of the three key pairs, novel_miR_40-*PsaK*, novel_miR_20-*PRO* and novel_miR_20-*CHI* pairs, was validated by qPCR and dual-luciferase assays. This study provides new insights into the molecular mechanism of miRNAs involved in *P. vivax* culm colour formation, during de-domestication, which is helpful for revealing the evolutionary mechanism of bamboo.

Keywords: *Phyllostachys vivax* cv. *Aureocaulis*, culm color variation, de-domestication, comparative transcriptome, miRNA-mRNA networks

Physiological process determination and transcriptome analysis during seed germination of Moso bamboo

J. Li*, Y.C Bai, Y.L Xie, J. Gao

International Centre for Bamboo and Rattan, Beijing, China
ljgx2003@126.com (*Corresponding Author)

Abstract: This research explores physiological process of seed germination, the mechanisms in the main pathways during seed germination and the mechanism of gibberellic acid treatment on seed germination, that could be used as the foundation for bamboo seed production, expansion breeding, and research.

The results indicated that: (1) the optimum seed water content of moso bamboo using different storage times was 12.4%, after moderate drying of fresh seeds, seed water decreased, germination rate increased, respiration rate decreased, and seed vigor increased. However, with the extension of storage time, seed water content decreased, and the seed germination rate, germination potential, and vigor index decreased, seed water content of moso bamboo largely influences vitality index and respiratory; (2) the degradation of carbohydrates including lipid and starch metabolism play an important role in providing energy during seed germination of moso bamboo. Total starch and crude oil decreased and the starch metabolism and the lipid body degradation pathway genes were consistently upregulated during moso bamboo seed germination. AP2 and bHLH proteins were the most common upregulated transcription factors related to seed germination and may play significant roles in seed germination. (3) The low gibberellic acid concentration treatment on germination seed accelerated the decomposition of starch and fat and promoted the vacuole formation of cells, but the high gibberellic acid

concentration damaged organelles and increased the endocytosis of cells. After gibberellic acid treatment, *GID1* and *DELLA*-related genes homologous to rice genes is not expressed, but the expression of *PIF4*, *PIF5*, *GA₃ ox2*, *GA_{20xs}*, etc., were up-regulated.

Keywords: *Moso bamboo, seed germination, physiological indexes, transcriptome analysis, gibberellic acid treatment*

Bamboo site-species suitability matching in the Kenyan agro-climatic environment

Gordon Sigu Onduru, Margaret Kaigongi, John Otuoma, Nellie Oduor

*Kenya Forestry Research Institute, Nairobi, Kenya
gsigu@kefri.org*

Abstract: Bamboo has been planted in Kenya for about three decades. Most of the planted bamboo comprise exotic species, which have been introduced into the country at different stages. Their introduction remains uncoordinated hence there is information gap regarding existing bamboo resource base of planted, the growth performance of bamboo planted in different agro-ecological zones and potential return on investment. This has hampered widespread adoption of bamboo in the county. In this regard, a bamboo species-site suitability assessment was carried out in order to match each bamboo species to the most suitable different agro-ecological zones (AEZ) in Kenya.

This paper outlines the results of the assessment with regard to the origin of bamboo species that are planted in Kenya, their growth performance in their native range, their performance in different agro-ecological zones in the country, and their potential for ecological and socio-economic utilization in different parts of the country.

The paper identified one indigenous and 15 exotic bamboo species. The native bamboo species is *Oldeania alpina* (Syn. *Yushania alpina*), while the exotic species are *Thyrsostachys siamensis*, *Phyllostachys aurea*, *Oxytenanthera abyssinica*, *Dendrocalamus strictus*, *D. membranaceus*, *D. hamiltonii*, *D. giganteus*, *D. brandsii*, *D. birmanicus*, *D. asper*, *Bambusa tulda*, *B. multiplex*, *B. blumeana*, *B. bambos*, *B. vulgaris* var. *vulgaris* and *B. vulgaris* var. *vittata*.

The site suitability analysis indicated that *O. alpina* was unsuitable for plantation establishment outside its natural range of 2,300 – 3,200 m above sea level. Other introduced species varied in performance in different AEZ.

Keywords: *bamboo species, site matching, agro-ecological zones, Kenya*

The investigation and research of bamboo resources in Danxia mountain

Yihua Tong¹, Jingbo Ni¹, Yuling Huang^{1,2}, Fang Chen³, Nianhe Xia^{1*}

¹ Key Laboratory of Plant Resources Conservation and Utilization & Guangdong Provincial Key Laboratory of Digital Botanical Garden, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou, China
nhxia@scbg.ac.cn (*Corresponding Author)

² University of Chinese Academy of Sciences, Beijing, China

³ Administrative Commission of Danxia Mountain National Park, Shaoguan, China

Abstract: Bamboo is an important kind of forest resources. The investigation and research of bamboo resources play an important role on the sustainable development of bamboo industry and the scientific researches of bamboos. Danxia Mountain is the largest scenic spot in Guangdong Province, which harbours a high biodiversity due to its special geological conditions. However, a targeted investigation and research on bamboo resources in Danxia Mountain has never been conducted until now. Thus, a comprehensive investigation of bamboo resources in the whole area of Danxia Mountain was carried out from April, 2019 to May, 2022, and the results showed that the bamboos in Danxia Mountain are relatively high in diversity and endemism: (1) 45 bamboo species belonging to nine genera were recorded, while only 17 species were recorded in the last survey in 2011; (2) three new taxa were discovered, viz. *Phyllostachys danxiaensis* N. H. Xia & X. R. Zheng, *pulverulentoides* N. H. Xia, J. B. Ni, Y. H. Tong & Z. Y. Niu and *Bonia saxatilis* var. *danxiaensis* X. Li, J. B. Ni & Y. H. Tong; (3) two of the 13 wild bamboo species distributed in Danxia Mountain are endemic, which shows a relatively high proportion of endemism. After a thorough study on the composition, areal-types, utilization and distribution of all species, the number of species and distribution of bamboo resources in Danxia Mountain are almost clear. This research will be helpful for the future development and utilization of bamboo resources and the biodiversity research in Danxia Mountain.

Keywords: bamboo, taxonomy, diversity, endemism, plant resources

Morphological characteristics and transcriptome comparisons of the shoot buds from flowering and non-flowering *Pleioblastus pygmaeus*

Wenjing Yao, Shuyan Lin*, Li Ren, Yawen Wan, Li Zhang, Yulong Ding

Co-Innovation Center for Sustainable Forestry in Southern China/Bamboo Research Institute, Nanjing Forestry University, Nanjing, China
lrx@njfu.com.cn (*Corresponding Author)

Abstract: Bamboo plants have a distinctive life cycle with long flowering periodicity. Many species remain in vegetative growth for decades, followed by large-scale flowering and subsequent death. Floral transition is activated while shoot buds are still dormant in bamboo plants. In this study, we performed morphological characterization and transcriptome analysis

of the shoot buds at different growth stages from flowering and non-flowering *Pleioblastus pygmaeus*. The morphological and anatomical structures of the dormant shoot buds were similar in flowering and non-flowering plants, while there was an obvious difference between the flower buds from flowering plants and the leaf buds from non-flowering plants. The transcriptomes of the dormant shoot buds, germinated shoots, and flower buds from flowering *P. pygmaeus*, and the dormant shoot buds, germinated shoots, and leaf buds from non-flowering *P. pygmaeus* were profiled and compared by RNA-Seq. The identified sequences were mostly related to metabolic synthesis, signal transmission, translation, and other functions. A total of 2434 unigenes involved in different flowering pathways were screened from transcriptome comparisons. The differentially expressed unigenes associated with the photoperiod pathway were related to circadian rhythm and plant hormone signal transduction. Moreover, the relative expression levels of a few key flowering-related genes such as *CO*, *FT*, *FLC*, and *SOC1* were quantified by qRT-PCR, which was in accordance with RNA-Seq. The study revealed morphological differences in the shoot buds at different growth stages and screened flowering-related genes by transcriptome comparisons of the shoot buds from flowering and non-flowering *P. pygmaeus*, which will enrich the research on reproductive biology of bamboo plants and shed light on the molecular mechanism of the floral transition in bamboo plants.

Keywords: *Pleioblastus pygmaeus*, flowering pathways, shoot buds, floral transition, RNA-Seq

Role played by bamboo roots in substrate growth and life enhancement for aquatic life

D. Waruiru

*Department of Water, Irrigation, Environment and Climate Change, County Government of Nyeri, Nyeri, Kenya
danson851@gmail.com*

Abstract: Bamboo grown on wetlands usually are known to have a commensalism type of relationship with the phytoplanktons which is usually food for aquatic life. Bamboo can be grown without the use of chemical fertilizer and pesticides. It can be grown 100% organically. A naturally occurring bioagent protects the roots of the Bamboo from destructive fungus and bacteria microbes and equally protects the phytoplanktons which is food to the aquatic life. This maintain the PH of their environs at alkaline. This again is an eco-friendly property of the bamboo plants. Thus when aquatic life especially fish eat the phytoplanktons the take in form of alkaline nature contrary to the absence of the bamboo plant. Besides roots, the bamboo leaves are not allelopathic and therefore the falling leaves are not detrimental to the aquatic life ecosystem.

Bamboo act as buffer for purifying run of that might be harmful to organisms in the water. It has very high dense root system and resistant to many environmental stresses. By this it is able to remove impurities and pollutants from the run off cushioning the life in the water. Dense network of rhizomes is very effective at phytoremediation, the process of using plant matter to filter water and remove organic and inorganic contaminants. The plant tissue of Bamboo

absorbs contaminated water and removes, stabilizes or destroys harmful substances.

Keywords: *bioagent, allelopathic, buffer, cushioning, phytoremediation*

Research on stand structure and rhizome characteristics of *Phyllostachys edulis* in different expansion stages

Wang Yikun¹, Ren Shuxiao², Ji Xinliang³, Ma Yi³, Zhu Qianggen¹, Jin Aiwu^{1*},
Fang Wanli³

¹ Lishui College, Lishui, China
kinaw@zafu.edu.cn (*Corresponding Author)

² State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University, Hangzhou,
China

³ Longquan Protection Center of Qianjiangyuan-Baishanzu National Park, Longquan, China

Abstract: The differences of stand structure and rhizome characteristics in different stages of expansion of *Phyllostachys edulis* into coniferous and broadleaf forest were explored. Forest land in competitive exclusion stage (A), advantage maintenance stage (B) and Long-term advantage maintenance stage (C) were targeted in Fengyang Mountain, Zhejiang Province. Redundancy analysis and Heatmap was used to reveal the relationships among the rhizome characteristics of *Phyllostachys edulis*, stand structure, soil physicochemical properties and soil fauna. During the process of the expansion of *Phyllostachys edulis* into coniferous and broadleaf forest, density of *Phyllostachys edulis* increased, but DBH decreased. The rhizomes were most distributed in the 0-10 cm soil layer, and the biomass of adult rhizomes in *Phyllostachys edulis* forest were significantly higher than that in other forests. The biomass of adult rhizomes and aging rhizomes of *Phyllostachys edulis* were positively correlated with density of *Phyllostachys edulis* forest, and the length and diameter of rhizomes of *Phyllostachys edulis* were positively correlated with DBH of *Phyllostachys edulis*. The soil bulk density, soil organic matter and total nitrogen were positively correlated with biomass of young rhizomes of *Phyllostachys edulis*, and negatively correlated with biomass of aging rhizomes of *Phyllostachys edulis*. The density of *Prostigmata*, *Onychiuridae* and *Mesostigmata* had a significant negatively correlation with the density and DBH of *Phyllostachys edulis*, and the density of *Prostigmata* and *Sminthuridae* had a significant positively correlation with the biomass of aging rhizomes of *Phyllostachys edulis*. The long-term expansion of *Phyllostachys edulis* into coniferous and broadleaf forest will lead to the decline of the stand structure and rhizome of the *Phyllostachys edulis* forest, and human intervention can be appropriate to maintain the ecological function of the *Phyllostachys edulis* forest.

Keywords: *Phyllostachys edulis* expansion, stand structure, rhizome, soil physicochemical properties, soil fauna

The biomass of understory vegetation in *Qiongzhusua tumidinoda* forest showed the optimal allocation with the increase of soil layer thickness

Wu Y.Y.^{1,2}, Dong W.Y.², Zhong H.², Pu C.³, L. X.³, Xie Z.X.³

¹Key Laboratory of State Forestry Administration of Biodiversity Conservation in Southwest China, College of forestry, Nanjing Forestry University, Nanjing, China

²Institute of Qiong Bamboo, Southwest Forestry University, Kunming, China

³Daguan County Forestry and Grassland Administration, Zhangtong, China

Abstract: To disentangle the distribution pattern of understory vegetation biomass is a significant content to study the material cycle of bamboo forest ecosystem. However, previous studies have focused mainly on the change pattern of vegetation and bamboo biomass, with much less attention given to the relationship between biomass and environmental factors. Here, we investigate the distribution law of understory biomass vegetation and the relationship between plant biomass distribution characteristics and soil properties in *Qiongzhusua tumidinoda* forest with soil depths of 0 ~ 40 cm, 0 ~ 80 cm and 0 ~ 120 cm.

The aboveground biomass and underground biomass of shrubs and herbs increased with increasing soil thickness, and the biomass allocation of understory vegetation was in accordance with the optimal partition theory, i.e., comparing with the medium soil layer and thick soil layer habitats that possess relatively sufficient water and nutrients, the understory vegetation in the thin soil layer habitat preferred to allocate biomass to the restricted underground parts; compared with the medium and thick soil layers, the biomass allocation of understory vegetation in the thin soil layer had more stronger plasticity and adjustment ability due to the limitation of soil moisture and nutrient resources; there were different degrees of correlation between vegetation plant biomass and soil physical and chemical properties. Among them, capillary porosity and total potassium were two main soil physicochemical factors affecting the allocation of understory vegetation; Shrub and herb biomass are closely related to bamboo biomass, and their interpretation amounts are as high as 99.1%.

The biomass of understory vegetation in bamboo forest showed the optimal allocation with the increase of soil thickness. The growth of understory vegetation can be improved by loosening soil and applying potassium fertilizer, which will help to promote the biomass accumulation of *Q. tumidinoda*.

Keywords: understory vegetation, biomass, soil thickness, correlation, *Qiongzhusua tumidinoda*

Bamboo at the service of the preservation of the ecosystem

Tamwo Teboug Severin Hosely

Cameroonian Platform of Bamboo and Rattan Professionals, Yaoundé, Cameroon,
hoselyseve@yahoo.com

Abstract: One of the largest contributors of CO₂ emissions is the construction. To achieve the carbon neutrality by 2060, many countries like China needs to develop carbon reduction pathways for the construction industry. For many international's organization like International Bamboo and Rattan Organization INBAR, Bamboo is believed to be one of the most appropriate candidates for afforestation to reduce CO₂ concentration and alleviate the effects of climate change. This is why it is essential to reduce carbon emissions. With high tensile and compressive strengths, Bamboo is an ideal building material. Bamboo is a natural building material that can be found in the tropical to mild temperate regions. But the comprehension of the storage of bamboo building materials is not effective. Our study consists of the evaluation of the quantity of CO₂ emissions and carbon storage to analyse the potential reduce the Carbone emissions. Results show that the planting phase contributes the largest amount of carbon uptake whilst the production phase contributes the largest amount of carbon emissions. Carbonization appears to be the production process with the highest carbon emissions, followed by anticorrosion and drying treatment. Some strategies that are useful in reducing carbon emissions are proposed and validated. Compared to dimensioned lumber, engineered lumber, cement, steel, timber, hempcrete, bamboo building materials have the highest CO₂ emissions and carbon storage. This evaluation is estimated to assist not only researchers in understanding the carbon reduction potential of bamboo building materials but also practitioners in promoting bamboo building based carbon reduction pathways.

Keywords: bamboo building materials, carbon emissions, carbon storage, construction industry

Starch granules changes in bamboo shoots during the elongation growth of *Phyllostachys edulis* ‘Pachyloen’

Tianyi Hu^{1,2*}, Tingting Xu^{1,2}, Qiang Wei³, Guangyao Yang^{1,2}, Fen Yu^{1,2}

¹ College of Forestry, Jiangxi Agricultural University, Nanchang, China
1336264399@qq.com (*Corresponding Author)

² Jiangxi Provincial Key Laboratory for Bamboo Germplasm Resources,
Nanchang, China

³ Bamboo Research Institute, Nanjing Forestry University, Nanjing, China

Abstract: To reveal the material basis of *Phyllostachys edulis* ‘Pachyloen’ fast growth, and to further explore the mechanisms of fast growth of *Ph. edulis* ‘Pachyloen’, paraffin sections combined with optical microscopy techniques were used to study the temporal and spatial dynamics of starch granules in bamboo culms during the elongation growth of *Ph. edulis* ‘Pachyloen’. (1) Overall, the content of starch granules gradually decreased during the elongation growth of bamboo culms. In individual internodes, the content of starch granules varied from site to site. In the axial direction, the content of starch granules from top to bottom in the same internode increased, and the most was at the base of the internode. The content of starch granules in nodes was always higher than that in internodes. After the elongation growth ceased, there were still starch granules in the parenchyma cells. (2) In the radial direction, the starch granules gradually decreased from outside to inside, and there were obviously more starch granules around the vascular bundle than in other parts. (3) Abnormal diaphragm led

more starch granules in the culms and similar content of starch granules in each part of the internodes. The temporal and spatial dynamics of starch granules are consistent with the development of internode cells during the growth of *Ph. edulis* ‘Pachyloen’, and the nodes might regulate the elongation growth of bamboo mainly by controlling material transportation, which provides a basis for further exploration of the material metabolism mechanisms of the fast growth of bamboo culms.

Keywords: *Phyllostachys edulis* ‘Pachyloen’, elongation growth, starch granule, culm, node

Differential analysis and identification of noncoding RNAs in response to drought in bamboo

Yang Yang, Yuanmeng Gao, Yiqian Li, Xueping Li*

International Centre for Bamboo and Rattan, Beijing, China
lxp@icbr.ac.cn (*Corresponding Author)

Abstract: The role of noncoding RNAs (ncRNAs) in plant resistance to abiotic stresses is increasingly being discovered. Drought stress is one of the most common abiotic stresses encountered and has a deep impact. In this study, high-throughput sequencing was performed on plant tissue samples from 0, 2, 4 and 6 days of drought treatment *Phyllostachys aureosulcata* f. *spectabilis* C. D. Chu et C. S. Chao, and the sequencing results were analysed bioinformatically. We detected 336,946 ncRNAs among all 12 samples, including 192,098 message RNAs (mRNAs), 142,761 long noncoding RNAs (lncRNAs), 1,670 circular RNAs (circRNAs), and 417 microRNAs (miRNAs). We detected 15,015 differentially expressed (DE) ncRNAs, including 436 DE circRNAs, 14,347 DE lncRNAs and 232 DE miRNAs. Then, we used Gene Ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) to functionally predict DE ncRNAs. The results showed that most DE ncRNAs are involved in the response to drought stress, mainly in biochemical reactions involved in some metabolites, as well as in organelle activities. The mRNA-miRNA-circRNA-lncRNA interaction network was constructed. In addition, we validated two random circRNAs and demonstrated their circularity. We also found a stable internal reference gene available for goldenrod and validated the accuracy of this experiment by quantitative real-time polymerase chain reaction (qRT-PCR). This research will explore the ncRNA regulatory mechanism of bamboo drought response and provide genetic resources for bamboo molecular breeding.

Keywords: ncRNAs, drought stresses, GO enrichment, KEGG enrichment, miRNA decoys

Bamboo in the Brazilian hotel chain

G.F. Katiane¹, F. F. L Ana², F. Nivaldo³, F. D. Wanderlei⁴

¹ Brazilian Innovation And Sustainability Center, Londrina, Paraná. Brazil

presidencia@cebis.org.br

² *AFiorda Consulting and Advisory, São Paulo, Brazil*

³ *NF Bambuzeria, Santa Cruz do Sul, Rio Grande do Sul, Brazil*

⁴ *Wanderlei Daleci Furniture, Ariquemes, Rondônia, Brazil*

Abstract: In 2021, the ‘Bioeconomy in the hotel chain’ project was developed, focusing on the use of natural fibers, with a great emphasis on bamboo, with the proposal to replace non-renewable raw materials with renewable raw materials in hotel areas and articles, involving research and development of new products oriented to design and technological innovation.

Studies carried out by the researchers indicate that the largest purchases, in quantity/volume, of the hotel chain are items for personal and disposable use, such as cups, cutlery, shower caps, slippers and packaging of amenities. The large volume causes concern in waste management. The biggest purchases, of value, are the items with greater replacement of common and private areas. The most replacement items in the rooms: chairs, lamps, lamps, pillows, curtains and paintings. In the common areas, the carpets, decoration and furniture, such as sofas and tables, stand out. In wet common areas, which are outdoors, they also demand a large part of the maintenance budget. Another relevant point in the research was the possibility of domestic and decorative items in the kitchen and in restaurants.

The conclusion of the research points to several opportunities for the use of bamboo that would increase the perception and presence of sustainability. According to the survey, more than 70% of guests say that sustainability is an important factor in their booking. In addition to the items mentioned above, which could be replaced entirely by bamboo items, he emphasizes that bamboo can also be used in civil construction as a structure and finish, and in staff uniforms and accessories.

Keywords: *hotel, marketplace, guests, cebis, tourism*

Seed germination and seedling growth of *Dendrocalamus brandisii* in vitro, and the inhibitory mechanism of colchicine

Li Juan^{1,2,3}, *Ly Zhuo*^{1,2,3}, *Wang Shuguang*^{1,2,3*}

¹ *Key Laboratory for Sympodial Bamboo Research, Faculty of Life Sciences, Southwest Forestry University, Kunming, China*
*stevenwang1979@126.com (*Corresponding Author)*

² *Science and Technology Innovation Team of National Forestry and Grassland Administration, Southwest Forestry University, Kunming, China*

³ *Bamboo and Rattan College, Southwest Forestry University, Kunming, China*

Abstract: Bamboos seldom bloom and almost no seeds could be harvested, and, hence, few works are focused on germination physiology. Systematic research on the physiological effects of colchicine on germination and seedling growth of bamboo seeds is lacking. In this study, we finely recorded seed germination and seedling growth of *Dendrocalamus brandisii* in media supplemented with different colchicine concentrations. Physiological effects and mechanisms

of colchicine were analyzed. The results showed that *D. brandisii* seeds were non-dormant, and seed lots achieved their highest germination rates on the 4th day and finished the whole germination period after 21 days. Colchicine inhibited seed germination and seedling growth but did not change its germination pattern. Seed germination and seedling growth decreased constantly with colchicine concentration. Colchicine showed more negative effects on seedling growth than on seed germination and root growth. High concentrations of colchicine retarded the development of plumules and even caused their aberrant development. Under tissue culture conditions, seed germination, and seedling growth relied mainly on the endogenous starch and soluble sugar degradation, in which α -amylase, STP, and SUSY played the key role. Colchicine inhibited seed germination and seedling growth by suppressing the α -amylase, STP, and SUSY activities. Colchicine showed more negative effects on sucrose degradation than on starch degradation during seed germination and seedling growth. This study provides new basic information on the seedling physiology for the genetic breeding of bamboo plants.

Keywords: *bamboo seed, germination, seedling growth, sugar metabolism, inhibitory mechanism*

Harnessing remote sensing and model-based inference for predicting bamboo forest area in Fujian Province China

Q. Xu^{}, G. Liu, S. Wei, F. Guan, S. Fan*

*International Centre for Bamboo and Rattan, Beijing, China
qing.xu@icbr.ac.cn (*Corresponding Author)*

Abstract: Total area of bamboo forests in an administrative division is an important population parameter for understanding the capacity and potential for carbon sequestration of bamboo forests in this area. Remote sensing (RS) plays an essential role in predicting forest area at regional, national and international scales with model-based inference; however, prediction bias is large if sample is unbalanced, prediction uncertainty is unknown if model uncertainties are not accommodated at the population level. Aimed at an unbiased prediction for the total area of bamboo forests in Fujian Province as well as an estimator for the prediction uncertainty, this study constructed two logistic regression models that related RS variables that included spectral reflectance, vegetation indices, textural features, moisture features, to the field-observed bamboo forest probability, using an unbalanced sample and a balanced sample respectively. LandSat satellite images acquired in 2018 and 460 sample plots measured for the 9th China's National Forest Inventory (NFI) in Fujian Province were used to generate RS variables and the variable of interest. Multivariate Taylor series expansion was used to assess variance components associated with sampling process and model residuals, which were scaled up to the population level. By comparing the predicted total area using either unbalanced or balanced samples, with the prediction reported by the 9th China's NFI for Fujian Province, an overprediction as large as 68% was found with the unbalanced sample. Statistical properties of the sample distribution were found to have a large effect on prediction uncertainty and prediction bias.

Keywords: survey population, population parameter, prediction uncertainty, unbiased prediction, variance decomposition

An efficient genetic transformation and CRISPR/Cas9-based genome editing system for Moso bamboo (*Phyllostachys edulis*)

Biyun Huang^{1,2†}, Renying Zhuo^{1,2†}, Huijin Fan^{1,2}, Yujun Wang^{1,2}, Jing Xu^{1,2}, Kangming Jin^{1,2}, Guirong Qiao^{1,2*}

¹ State Key Laboratory of Tree Genetics and Breeding, Chinese Academy of Forestry, Beijing, China.

² Key Laboratory of Tree Breeding of Zhejiang Province, Research Institute of Subtropical of Forestry, Chinese Academy of Forestry, Hangzhou, China.

gr_q1982@163.com (*Corresponding Author)

† These authors have contributed equally to this work and share first authorship.

Abstract: Moso bamboo (*Phyllostachys edulis*) is the most important monopodial bamboo species worldwide. Without a genetic transformation system, it is difficult to verify the functions of genes controlling important traits and conduct molecular breeding in moso bamboo. Here, we established a plant regeneration system from immature embryos. Calli were induced on MS medium added 4~6 mg·L⁻¹ 2,4-dichlorophenoxyacetic acid (2,4-D) with high efficiency (>60%). A plant growth regulator combination of 0.5 mg·L⁻¹ 1-naphthylacetic acid (NAA), 2.0 mg·L⁻¹ 6-benzylaminopurine (BAP) and 3.0 mg·L⁻¹ zeatin (ZT) were suitable for shoot differentiation, and the shoot induction frequency was increased to 43% after 0.5 mg·L⁻¹ abscisic acid (ABA) pretreatment. An effective antibiotic screening concentration was determined by hygromycin sensitivity test. We further optimized the *Agrobacterium* concentration and added vacuum infiltration for infection, improving the transient expression efficiency. A genetic transformation system was established for the first time in moso bamboo, with transformation efficiency of approximately 5%. In order to optimize genome editing, two endogenous U3 small nuclear RNA (snRNA) promoters were isolated and used to drive small guide RNA (sgRNA) expression. The results showed that the *PeU3.1* promoter exhibited higher efficiency, and it was used for subsequent genome editing. Finally, homozygous *pds1pds2* mutants were obtained by an efficient CRISPR/Cas9 genome editing system. These technical systems will be conducive to gene functional validation and accelerate the molecular breeding process of moso bamboo.

Keywords: *Phyllostachys edulis*, immature embryo culture, plant regeneration, genetic transformation, genome editing

Allometric equations for above ground biomass and carbon content in bamboo based farm forestry systems in humid and semiarid zones: a case study of *Bambusa balcooa* Roxb

*Sruthi Subbana*¹, *Syam Viswanath*²

¹ *Bamboo Society of India, India*

² *KSCSTE-Kerala Forest Research Institute, Trichur, Kerala, India*
sruthisubbanna@gmail.com

Abstract: Over the years climate change has become the central point of conversation in the international arena with special significance to become a carbon neutral society. This study looks at the potential of bamboos, with special reference to *Bambusa balcooa*, in farm forestry for carbon sequestration. The study analyzed Above Ground Biomass (AGB) and carbon content in the bamboo species through destructive sampling across the humid and semiarid zones. Subsamples were brought to lab wherein culm AGB and C Content were estimated using standard procedures. It was observed that the culm AGB per hectare in a ten-year-old *B. balcooa* in semiarid zone is 75.75 Mgha⁻¹ which is almost equal to that of a six-year-old plantation in humid zones at 71.11 Mgha⁻¹ highlighting that the species grows best in humid zones.

In addition, regression equation models were developed to predict AGB and C Content. It produced significant fit for culm parameter for AGB in both humid ($r^2 = 0.795$, $p < 0.01$) and semiarid ($r^2 = 0.832$, $p < 0.01$) and for C Content in humid (0.813, $p < 0.01$) and semiarid zones (0.816, $p < 0.01$). The developed allometric equations could enable estimation of carbon sequestration potential of *B. balcooa* in farm forestry across different scenario building exercises helping create better pathways to achieve carbon neutrality. This paper, hence describes both the opportunities and the challenges of growing bamboo in a farm forestry set up and its potential in carbon sequestration to mitigate climate change and achieve carbon neutral goals.

Keywords: *Bambusa balcooa*, carbon neutral, carbon sequestration, bamboo, climate change

Pyrolysis characteristics and gaseous products of bamboo shoot shells in N₂ and CO₂ atmospheres

Yanmei Hou^{1,2}, *Zixing Feng*^{1,2}, *Yuyu He*^{1,2}, *Qi Gao*^{1,2}, *Liangmeng Ni*^{1,2}, *Hao Ren*^{1,2}, *Mengfu Su*^{1,2}, *Zhijia Liu*^{1,2*}

¹ *International Centre for Bamboo and Rattan, Beijing, China*

² *Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China*

*Liuzj@icbr.ac.cn (Zhijia Liu); wh0030@mix.wvu.edu (Wanhe Hu) (*Corresponding author)*

Abstract: Bamboo shoot shells (BSS) thermal decomposition under N₂ and CO₂ atmospheres was studied using thermogravimetric analysis at different heating rates (5, 10, 20 and 40

°C/min). Two iso-conversional kinetic methods (Kissinger-Akahira-Sunose and Flynn-Wall-Ozawa), thermodynamic parameters, and the compositions of gaseous products were determined and compared. Results showed that the variations of E_a on α/T produced strikingly different trends under two pyrolysis atmospheres. Master plot showed that the data of two atmospheres (N₂ and CO₂ peak 1) fits well with R₂, R₃, A₂ reaction model before 0.5 conversion and then follows F₂ reaction model. The experimental plots for second peak at CO₂ atmosphere followed R₂ and R₃ reaction model in lower conversion range (for $\alpha \leq 0.5$). The gaseous products in the pyrolysis process mainly included CO, CO₂, H₂O, CH₄, aldehydes, ketones, alcohols and aromatic compounds. The number of BSS gaseous products are much lower in N₂ atmosphere than in CO₂ atmosphere. Incorporating CO₂ waste streams into the biomass pyrolysis process would benefit for useful gases generation.

Keywords: bamboo shoot shells, pyrolysis, Kinetics, thermodynamic, gaseous products

Variations of silicon content and phytolith morphology characteristics in different organs of *Ferrocalamus strictus*

Rui Xu, Shuguang Wang, Changming Wang, Hui Zhan

Southwest Forest University, Kunming, China
xurui891019@163.com

Abstract: Silicon (Si) is the second most abundant element in soil. It is absorbed and biomineralized as diverse forms of phytoliths in the plant organs. The paper investigated the silicon variation and phytolith morphology in different organs of *Ferrocalamus strictus* in different growth stages. The research on phytoliths has progressed rapidly, and it is widely used in many disciplines such as plant taxonomy, paleoecology, zoology, geology, soil science, agronomy, and archaeology. The study of modern plant phytolith is of great significance to improve the accuracy of phytolith analysis. By systematically studying the silicon content, phytolith morphology and combination of different organs (root, rhizome, sheath, culm, branch and leaf) of 1-year, 2-year and 3-year, the results showed that the silicon content in different organs of *F. strictus* varied greatly, ranged from 4.49 to 173.16 g kg⁻¹, and increased in the order of leaf > sheath > branch > root > rhizome > culm, and the silicon content in some organs (the leaf, branch, rhizome and culm) were significantly correlated with bamboo age.

24 phytolith morphotypes were observed in in different *F. strictus* organs, which varied closely interrelated with the culm age. Branch, culm, root and rhizome were dominated by compound phytoliths. The phytolith in leaf was relatively abundant and were dominated by bilobate, long saddle, two-spiked rondel, stomata, elongate dentate, tabular gibbous, elongate bulbous, arm cell, acute and extended acute. The phytolith index of the 3-year leaf was less affected by climate and was relatively stable, could be used to evaluate the leaf transpiration and environmental conditions. This work will enrich the phytolith morphology Gramineae of grasses, help to establish a bamboo phytolith classification system, and provide a basis for phytolith analysis.

Keywords: organ, phytolith, phytolith morphotype, silicon, variation

Physiological response characteristics of Moso bamboo under drought stress based on Calcium signal

Xiong Jing, Shaohui Fan

International Centre for Bamboo and Rattan, Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, Beijing, China

Abstract: This study aimed to evaluate the dominant factors of physiological responses of *Phyllostachys edulis* (Carrière) J. Houz to drought stress. The calcium (Ca^{2+}) fluxes in root tips of *P. edulis* treated by polyethylene glycol were monitored via non-invasive micro-test technology. The physiological indexes of *P. edulis* under different soil moisture contents were determined. The regression model was built by curve fitting with the main physiological factors of *P. edulis* using PCA analysis. The variance contribution rates of the first three principal components of the physiological indicators were 75.0%, 13.3% and 5.0%. Calcium signal sensing protein kinase (CDPK) contents accounted for a larger contribution to the load of the first principal component. The contents of calcium signal sensor protein calmodulin (CaM) and calcium-dependent protein kinase (CDPK) increased. Meanwhile, drought induced strong Ca^{2+} influxes in root tips. Additionally, as the soil water content decreased, the contents of malondialdehyde (MDA), proline, betaine, jasmonic acid (JA) and abscisic acid (ABA) increased, and auxin (IAA) decreased in *P. edulis* leaves, strongly correlating with the CaM and CDPK contents. The calcium signal of *P. edulis* is activated and cascades plant physiological responses to drought stress. This study will provide physiological evidence for research regarding mechanisms of drought resistance of *P. edulis*.

Keywords: *Phyllostachys edulis*, drought stress, calcium ion, calcium sensing protein, drought resistance physiology

A comprehensive analysis of the floral transition in Ma bamboo (*Dendrocalamus latiflorus*) reveals the roles of *DIFTs* involved in flowering

Huijin Fan ^{1,2†}, Renying Zhuo ^{1,2†}, Huiyuan Wang ³, Jing Xu ^{1,2}, Kangming Jin ^{1,2}, Biyun Huang ^{1,2}, Guirong Qiao ^{1,2*}

¹ State Key Laboratory of Tree Genetics and Breeding, Chinese Academy of Forestry, Beijing, China

² Key Laboratory of Tree Breeding of Zhejiang Province, Research Institute of Subtropical Forestry, Chinese Academy of Forestry, Fuyang, China

³ Fujian Agriculture and Forestry University, Fuzhou, China
gr_q1982@163.com (* Corresponding author)

† These authors have contributed equally to this work and share first authorship.

Abstract: Bamboo has a unique flowering characteristics of long and unpredictable vegetative period, which differs from annual herbs and perennial woody plants. In order to understand the

molecular regulatory mechanism of bamboo flowering, a comprehensive study was conducted in ma bamboo (*Dendrocalamus latiflorus*), including morphological, physiological and transcriptome analyses. Differentially expressed genes related to the flowering pathway were identified by comparative transcriptome analysis. *DIFT1*, a homologous gene of *FT/Hd3a*, was significantly upregulated in flowering bamboo. Direct differentiation of spikelets from calli occurred and the downstream gene *API* was upregulated in the transgenic bamboo overexpressing *DIFT1*. Transgenic rice overexpressing *DIFT1* showed a strong early flowering phenotype. *DIFT1* and *DITFL1* could interact with *DIFD*, and *DITFL1* delayed flowering. It is presumed that *DITFL1* plays an antagonistic role with *DIFT1* in ma bamboo. In addition, the expression of *DIFT1* was regulated by CO, indicating that a CO-FT regulatory module might exist in ma bamboo. These results suggest that *DIFT1* is a florigen candidate gene with conservative function in promoting flowering. Interestingly, the results have shown for the first time that *DIFT2* can specifically interact with E3 ubiquitin ligase *WAV3*, while *DIFT3* transcripts are mainly nonsense splicing. These findings provide better understanding of the roles of the florigen gene in bamboo and lay a theoretical basis for regulating bamboo flowering in the future.

Keywords: *Dendrocalamus latiflorus*, flowering, florigen, flowering locust, flowering regulation

Innovating rattan cane identification through next-generation DNA barcoding

Benedikt G. Kuhnhauser^{1*}, Jason Stevenson¹, Rowan Schley², László Csiba¹, Sidonie Bellot¹, William J. Baker¹

¹ Royal Botanic Gardens Kew, London, United Kingdom

² University of Exeter, Exeter, United Kingdom

b.kuhnhaeuser@kew.org (* Corresponding Author)

Abstract: Correct species identification is one of the most fundamental prerequisites of biological research and industrial applications on rattan canes. There are 487 species of rattan worldwide, and they largely vary in country of occurrence, extinction risk, and cane characteristics. However, there is currently no means of identifying rattan canes as all diagnostic features of rattans species are removed on harvesting. This presents a major obstacle to sustainable management of wild resources and monitoring of supply chains. DNA barcoding has potential to make identification possible, but traditional barcoding using single genes is limited by insufficient discriminatory power in plants. Here, we present next-generation DNA barcoding approaches that embrace the wealth of genomic data that can be generated using new sequencing technologies. We build a species-level genomic reference dataset for 411 species (99%) of *Calamus*, the largest rattan genus. This dataset includes genome skims (plastomes), generalist Angiosperms353 target capture data (353 nuclear loci) and palm-specific PhyloPalm target capture data (970 nuclear loci). On this basis, we develop next-generation DNA barcoding approaches using sequence composition (e.g. Skmer), sequence similarity (e.g. VSEARCH) and phylogenetic placement methods (e.g. pplacer). This DNA identification

toolkit will enable cane identification where it has been impossible before. The laboratory and bioinformatic methods as well as the genomic reference datasets will be made freely and publicly available, providing a new tool that will help rattan traders to ensure sustainable sourcing and the prevention of illegal harvesting.

Keywords: *Rattan, cane, Calamus, DNA barcoding, identification*

Research on the application of bamboo landscape of human settlements in China

Ziyan Wang¹, Cheng Wang², Zehui Jiang³

*¹School of Architecture, Tsinghua University, Beijing, China
ziyanw93@163.com*

² Chinese Academy of Forestry Beijing, Beijing, China

³ International Centre for Bamboo and Rattan, Beijing, China

Abstract: The bamboo landscape of human settlements refer to the combination between the visual landscape presented by various types of space composed of bamboo and the bamboo cultural landscape reflected in people's ideology in the human settlements. Therefore, this paper mainly discussed the application of bamboo landscape in the human settlements of our country from two aspects of vision and consciousness, and discussed characteristics and differences of bamboo landscape application in the north and south through urban and rural settlements respectively. Our country has abundant resources of bamboo landscape and takes the leading position in the world, but the research on bamboo landscape in human settlements was still relatively scarce, and the perspectives and methods of the research were also single. In view of the above problems, this paper put forward interdisciplinary and multi-perspective research on bamboo landscape in human settlements, such as bamboo cultural gene mapping research based on human geography, bamboo landscape modeling research using visualization technology and spatial patterns research at the macroscopic scale and so on, and studied the bamboo landscape of human settlements thoroughly and systematically to improve the framework system of bamboo landscape research related with human-settled in China, which can make full use of the advantages of the title "A country with the most abundant bamboo in the world" and promote the application and development of bamboo landscape in urban and rural areas in China.

Keywords: *bamboo landscape, cultural gene map, bamboo park, human settlements, visualization*

Effect of pyrolysis heating rates on fuel properties of molded charcoal: imitating industrial pyrolysis process

Hao Ren, Liangmeng Ni

*International Centre for Bamboo and Rattan, Beijing, China
hao991105@163.com*

Abstract: To investigate the relationship between fuel properties and pyrolysis heating rates (PHRs) of molded charcoals (MCs), biomass briquettes (manufactured by 70% bamboo and 30% wood blends) were pyrolyzed using various PHRs based on industrial production stages (preheating, primary pyrolysis, and carbonization stage). Proximate and ultimate analyses, as well as thermogravimetric and kinetics analyses, were performed for MCs. Results showed that PHRs had a significant effect on the quality and yield of MCs at the primary pyrolysis stage. Based on the production efficiency and energy performances, the PHRs were suggested to 5 °C/min, 1 °C/min, and 5 °C/min for preheating, primary pyrolysis, and carbonization stages. The higher heating value, energy enrichment factor, calorific value improvement, energy yield, and fuel ratio of optimal MCs were 34.02 MJ/kg, 1.777, 1.716, 71.65 %, 55.27, and 11.51, respectively. The MCs had a minimum activation energy of 98.57 KJ/mol. The findings of this study will be useful in understanding and standardizing the manufacturing process of MCs.

Keywords: *bamboo, Chinese fir, molded charcoal, heating rate, energy properties*

Adaptation of bamboo and rattan to climate change (CC) and carbon neutrality, in South Western Cameroon (SWC)

E.A Eneme¹, P. Sama-Lang², O.N. Bessong¹

*¹ South West Development Authority (SOWEDA), Buea, Cameroon
agnes.eneme@gmail.com*

² University of Buea, Buea, Cameroon

Abstract: In the rural areas of SWC, at the Gulf of Guinea, the South West Development Authority (SOWEDA) is in a growing trend to create adaptation strategies to Climate Change (CC). Using Bamboo and Rattan (BAR), SOWEDA and the Cameroon and Central African office of International Network for Bamboo and Rattan (INBAR), in a growing Bamboo and Rattan value chain, targets carbon neutrality in one (1) of its adaptation strategies. Existing Bamboo and Rattan potentials are being identified at the foot slopes of the Cameroon Mountain (CaM), the Rumpi Hills (Rumpi) and the Muanenguba Mountain (MaM). With INBAR negotiations, carbon neutrality was high at the first African congress on BAR, and developing its value chain was proposed based on the Cameroon Environment Law.

Agroforestry systems with Bamboo and Rattan are envisaged as a strategy to balance overexploitation. It is expected this initiative will help to rebuild carbon stocks, create greater green cover, and to also reduce incidence of landslides and floods. As a non-timber forest product (NTFP) Bamboo and Rattan will be more available to replace the misuse of timber for

finished products. Through vulnerable populations, an increase adaptation to CC, through carbon neutrality strategies will ensure restoration, conservation of biodiversity and the forest ecosystem.

Keywords: *climate change, restoration, carbon neutrality, biodiversity, agroforestry*

Bamboo-based socio-ecological systems for mining land degradation neutrality (mLDN)

Kamesh Salam

South Asia Bamboo Foundation, Guwahati, Assam, India

Abstract: Mining is the largest reducer of ecosystem provisioning, primarily through acquisition, then land degradation. The Government of India, in 2018, mandated regrassing of landforms by mining industries. Bamboo-led phytoremediation near Allahabad restored 4,000 ha of land ravaged by mining over 20 years; 786, 000 people in 96 villages are again cultivating food (also energy) crops; birds and animals are back in their old habitats. Biomass provides some electricity; biogas is used for cooking. A bamboo-centric plantation to semi-industrialized production ecosystem is a viable option for mLDN and also developing climate adaptive capacities of 10-15 million miners on over 300,000 hectares of land, where anthropogenic activities are slated to exponentially increase for economic growth and green technology development.

Government directives to mining industries ensure fund availability (estimated at about USD one billion) to address mLDN. CAMPA has disbursed USD six billion to states for reforestation; a reasonable estimate for rehabilitation would be USD 600/18,000 per person/hectare, respectively. GEF/ODA are available to reduce vulnerability of communities to climate impacts. Impact investments (USD 2.3 trillion in 2021) focus on ESG alongside financial returns; and bamboo industrial ecosystems meet risk-return standards of investment managers. They have demonstrated commercial viability at scale in China (Anji county), and pockets in India. This paper elaborates on: the pathway from plantation to industrialized production within a circular economy for LDN as demonstrated in Asia and Africa; and the trend of increasing impact investments to build resilience of vulnerable communities.

Keywords: *socio ecological, mining, degradation, restoration*

Creating E-bamboo mobile health clinics for communities

Dulce Blanca T. Punzalan^{1}, Ronald S. Balane², Christian S. Camacho³*

*¹Filbamboo Exponents, Inc., Quezpn City, Philippines
dulzbtp@yahoo.com (*Corresponding Author)*

²*University of the Philippine College of Architecture, Diliman, Quezon City, Philippines
rsbalanel@up.edu.ph*

³*Department of Science and Technology-Forest Products Research and Development
Institute, Los Banos, Laguna, Philippines
christian.camacho@fprdi.dost.gov.ph*

Abstract: The World Health Organization emphasizes that “the enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, and political belief, economic or social condition”

Amidst the global COVID-19 pandemic, this paper discusses the value proposition of creating E-Bamboo Mobile Health Clinics “to serve as ancillary services to the operations of the recipient hospitals most especially in priority, underserved, hard to reach and remote areas “A mobile clinic is a self- contained vehicle employed with a medical team aimed to provide health care services. The advantages and challenges of using Engineered Bamboo (modular) for the clinic’s customized interiors, as well as human resources (capacity building of the medical team), logistical and functional criteria, financial viability and technical requirements (including basic equipment) of the said clinic will be presented. Identification of targeted areas, creation of patient database, multisectoral partnerships (public and private sector, healthcare practitioners, civil society, peoples’ organizations, academe and research institutions) will be highlighted, together with current local and international studies on existing mobile healthcare and key areas for improvement (facilities and medical services offered, operational and maintenance expenses, problems encountered during implementation, insights gained, level of stakeholder satisfaction and perception, etc.).

Bamboo plays a vital role in people’s health -- nutritious food from shoots; refreshing beverages; pharmaceuticals, nutraceuticals and personal care products, etc. Bamboo framed face shields and bamboo fabric face masks are being utilized by frontliners. Bamboo prosthetic limbs and wheelchairs, tent designs and quarantine/ isolation facilities with bamboo beds and furniture were likewise put up. The health benefits of bamboo charcoal products, “green packaging”, bamboo bikes and bamboo textile are rapidly gaining recognition. Bamboo music and art therapy are included not only in cultural endeavors, but also in psycho-social interventions. Thus, the value proposition of creating accessible, affordable E- bamboo mobile health clinics is paramount.

Keywords: *bamboo innovations, mobile clinic, healthcare, environmental stewardship, vulnerable sectors*

Assessment of changes in the bamboo resources of India over a decade

*Anugrah Tripathi * , H.S. Ginwal, Ajay Thakur, Santan Barthwal,
Charul Kainthola*

*Indian Council of Forestry Research and Education, Dehradun, India
dranugraht@gmail.com (*Corresponding author)*

Abstract: India possesses the third position in bamboo genetic resources after China and Brazil but embraces the largest bamboo-bearing area across the world. Bamboo is a fast-growing arborescent grass species. Due to rapid growth behaviour, Bamboo commonly enjoys a high ability to capture and sequester atmospheric carbon and consequently mitigate climate change. The Forest Survey of India (FSI) is the authority to assess and monitor the forest resources of India for two years of interval. According to FSI estimates, bamboo bearing area of India is 149443 Km² whereas the bamboo-bearing area was recorded as 139577 Km² in 2011 which resulted in the increase of 9866 Km² over a decade. The total number of bamboo culms at the country level in recorded forest area is 53,336 which corresponds to an increase of 30,039 culms over a decade as 2011 estimates revealed total culms as 23297. This substantial increase in the bamboo resources of India may help to fulfill the INDCs of India in the Paris convention (2015) to create an additional carbon sink. To popularize the cultivation of bamboo in non-forest areas, in 2017, the Government of India amended Indian Forest Act (1927) and exempted bamboo grown in non-forest areas from the requirement of felling/transit permit. It is a paradigm shift towards the commercialization of bamboo as an enterprise at farmers' level. It will surely generate opportunities for the communities, farmers dwelling in the rural areas and fringes of the forests as well as bamboo utilizing industries for the bamboo.

Keywords: bamboo, genetic resources, climate change, forest survey of India

An environmentally friendly and efficient method to improve acoustic vibration performance of bamboo for musical instruments: nitrogen-protected heat treatment

Liping Deng^{1,2}, Fuming Chen^{1,2}, Xueyong Ren³, Zehui Jiang^{1,2*}*

¹ *Department of Biomaterials, International Centre for Bamboo and Rattan, Beijing, China*

² *Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China*

³ *College of Material Science & Technology, Beijing Forestry University, Beijing, China*

Abstract: The traditional drying process is very important to the acoustical quality of bamboo musical instruments, such as Jinghu. However, this technique has inherent challenges such as a complicated process, long cycle times, and ineffective quality control. In this study, heat treatment under nitrogen protection was used to determine the effects of different temperatures (160 °C, 190 °C, and 220 °C) and durations (0.5 h, 1.5 h, 2.5 h, and 3.5 h) on the acoustic vibration performance of bamboo. The measured and calculated variables included specific dynamic elastic modulus E'/ρ , loss tangent $\tan\delta$, and acoustical converting efficiency ACE. With respect to microstructure and physical properties, the mechanism of how heat treatment affects the acoustic vibration properties of bamboo was determined. Results showed that (1) appropriate heat treatment under nitrogen protection can significantly improve the acoustic vibration properties of bamboo. Within the scope of this study, the optimal heat treatment conditions were heating at 160 °C for 3.5 h under nitrogen protection (type I). Compared to the control group, the E'/ρ and ACE values of type I heat-treated bamboo increased by 2.0% and

37.0%, respectively, and the $\tan \delta$ decreased by 30.4%. (2) In terms of physical properties, the porosity of type I heat-treated bamboo increased from 31.6% to 35.2%, which increased the permeability along the longitudinal vibration of the bamboo. (3) In terms of chemical components, the concentration of the starchy substance in the parenchyma cell lumen of type I heat-treated bamboo was significantly less as it was degraded and volatilized. The content of hygroscopic hemicellulose was reduced from 25% to 21% due to pyrolysis, while the cellulose and lignin maintained their structural stability, thereby improving the bamboo's ability to resist ambient humidity changes. (4) On the molecular scale, the microfibril angle (MFA) of type I heat-treated bamboo was reduced from 12.54° to 10.54°, and the crystallinity increased from 34.8% to 36.5%. Type I heat treatment improved the orientation degree of the bamboo cell wall fibrils and adjusted the distance between cellulose molecular chains.

Keywords: bamboo, heat treatment, acoustic vibration efficiency, acoustic vibration stability, improvement mechanisms

The shoot-root junction limited the oxygen transportation in *Phyllostachys violascens*

Wuyuheng He, Shixin Deng, Renyi Gui*

State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University, Zhejiang, China
gry@zafu.edu.cn (*Corresponding author)

Abstract: With the widespread and perennial use of bamboo forest covering technology, the oxygen in bamboo forest land is insufficient, resulting in the floating of bamboo root whip. Hypoxia stress inhibits root growth and physiological metabolism, which ultimately leads to poor growth of *Phyllostachys violascens* forest and yield loss in bamboo shoot. In order to find out the main position that restricts oxygen transport of *Phyllostachys violascens*, three aspects of research were carried out in this paper. The results show that: (1) With the increase of dissolved oxygen concentration in nutrient solution, the root system activity, antioxidant enzyme activity and photosynthetic pigment content of *Phyllostachys violascens* hydroponics seedlings gradually increased. The formation of dissolved aerated tissue in the root system of *Phyllostachys violascens* was observed. (2) Potted seedlings of *Phyllostachys violascens* with obvious underground whip are not resistant to flooding, and long-term flooding will lead to their death, but higher dissolved oxygen concentration can prolong their survival time. (3) The ventilatory capacity of all parts of *Phyllostachys violascens* was significantly lower than that of *Phyllostachys heteroelada oliver* and *Phragmites australis* ($P < 0.05$). The critical value of ventilation at the joint (screw) between the stem and the underground whip of *Phyllostachys violascens* is 0.2MPa, which is significantly higher than that of *Phragmites australis* and *Phyllostachys heteroelada oliver*, indicating that the screw limits the transportation of oxygen above and below the ground. (4) The pith cavity at the screw of *Phyllostachys violascens* disappears, only a large number of vascular bundles are densely distributed, and there is no ventilation pipe in the body of *Phyllostachys heteroelada oliver* and *Phragmites australis*, resulting in the porosity of *Phyllostachys violascens* screw is significantly lower than that of *Phyllostachys heteroelada oliver* and *Phragmites australis*.

Keywords: *Phyllostachys violascens*, *Phyllostachys heteroclada* Oliver, *Phragmites australis*, oxygen transport, tissue ventilation

How bamboo hotspot services could accelerate bioenergy transition in Africa

Xiaoying Liu^{1,2*}, Gloria Asare Adu^{3,4}, Luc Boeraeve^{1,5,6}, Marigold Adu⁴

¹ Natureherit DC, Shanghai, China

² Sino-EU Panel on Land & Soil (SEPLS), Rotterdam, the Netherlands
xyliu@natureherit.com (*Corresponding Author)

³ Women Sustainable Charcoal Producers (WSCP), Anyinam, Ghana

⁴ Global Bamboo Products Limited (GBPL), Anyinam, Ghana

⁵ American Bamboo Society (ABS), California, USA

⁶ Belgium Bamboo Society (BBS), Poperinge, Belgium

Abstract: Burning fossil fuels and deforestation make together the largest causes of severing climate change by releasing greenhouse gas emission and destructing carbon sinks.

Renewable energy in the form of bioenergy from sustainably managed forests and bamboo, as well as from non-toxic, plant-based biowaste from forest and park management, agricultural and industrial processes, combines two major causes into one remedial action to replace fossil fuels and avoid deforestation. In other words, if deforestation could be stopped globally and bioenergy could replace fossil fuels sustainably, climate change effects could drastically be reduced or even reversed!

Transition to the use of Bioenergy transition is extremely urgent in Africa - world's 2nd largest and the only continent that still increases deforestation - all tropical forest, while energy demand is growing fast. Although climate-environmental benefits and market potentials are proven, it remains a complex issue after many years of efforts from international and - governmental organisations, African governments, bioenergy related sectors and wider stakeholders.

Because of suitable climate and as perfect replacement for timber, bamboo is a crucial feedstock for the bioenergy transition towards carbon neutrality in Africa, together with other suitable biowaste - wood, rice husk, weeds etc. Future carbon-neutral energy infrastructure should embed bamboo development. To join governmental and sectoral, international and domestic efforts in accelerating the process, this practical research suggests two interlinked actions:

1. Fostering the use of pellets and briquettes

Latest technical and market developments with bamboo and other feedstocks show that, pellets and briquette are effective and greener alternatives for the dominating charcoal and firewood use in household and industries in Africa;

2. Creating Bamboo Hotspot Services

In consultation with related institutions, this new approach combines innovation in value

chains and spatial planning, development of entrepreneurship and public-private partnerships, with relevant case studies in Ghana, Sierra Leone and Nigeria.

Keywords: *climate change, deforestation, bioenergy, pellet, spatial planning*

Bamboo as catalyzer for sustainable development in circular economy

Kim Yrjälä¹, Muthusamy Ramakrishnan², Lizeth Chino Carvajal³, Naresh Vasupalli⁴

¹ *Department of Forest Sciences, PB 27 (Latokartanonkaari 7), University of Helsinki, Helsinki, Finland*

² *Co-Innovation Center for Sustainable Forestry in Southern China, Bamboo Research Institute, Key Laboratory of National Forestry and Grassland Administration on Subtropical Forest Biodiversity Conservation, College of Biology and the Environment, Nanjing Forestry University, Nanjing, China*

³ *Forestry department, Nanjing Forestry University, Nanjing, China*

⁴ *State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University, Hangzhou, China*

Abstract: The pyrolysis of bamboo biomass shows great potential for combatting environmental challenges. In addition to the carbonaceous compound, biochar, it produces gas, and pyrolysis oils that can be valorized in the circular economy. Thus, bamboo can become an important factor for local sustainable economy in many countries. Bamboo is ecologically important and is a renewable biomass to produce biochar and activated carbon that have high water-, nutrient- and contaminant retention potential. They persist in nature and are ways of carbon removal on the way to carbon neutrality. Certain bamboo species such as moso bamboo, *Phyllostachys praecox*, have a high endurance in metal contaminated soils that can be taken advantage of for uptake and accumulation of heavy metals in plants in phytoremediation. Despite its economic and ecological value, the genetics of its growth, development and stress resilience, have poorly been studied. Conventional breeding is very slow due to long flowering intervals as moso bamboo has very infrequent flowering, extending, in general, for up to 120 years. The availability of the chromosome-level genome sequence of moso bamboo has accelerated the genetic study of bamboo. State-of-the-art biotechnologies now provide alternative strategies to study and develop bamboo, a crop in which agronomic traits are cumbersome to engineer with conventional breeding techniques. In our presentation, we summarize genomic, transposon-related, transcriptomic and proteomic field studies of moso bamboo, and discuss the potential of bamboo genome engineering for developing bamboo with traits desirable for industrial productivity and innovative economic uses.

Keywords: *biochar, circular economy, pyrolysis, moso bamboo, genomic field studies*

Combined intensive managements regulate soil bacterial communities and functional capacities by altering soil potassium and pH in a Moso bamboo forest

Y. Zheng^{1,2†}, X.Z. Liu^{1†}, Y.J. Cai¹, Q.S. Shao^{1,2}, W. Zhu³, X.C. Lin^{1*}, A. Micheal¹, B.C.D. Eric², F. Great³

¹ State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University, Hangzhou, China

² Zhejiang Provincial Key Laboratory of Resources Protection and Innovation of Traditional Chinese Medicine, Zhejiang A&F University, Hangzhou, China

³ Protection of Ecological Forestry Research Center in Huzhou, Huzhou, China
linxcx@163.com (*Corresponding Author)

† These authors have contributed equally to this work and share first authorship

Abstract: Intensive management is a common practice in agricultural and forestry ecosystems to improve soil quality and crop yield by influencing nutrient supply and soil microbiota; however, the linkage between soil nutrients and bacterial community and functional capacities in intensively managed economic forests has not been well studied. In this study, we investigated the soil properties such as available potassium (AK), available nitrogen (AN), available phosphorus (AP), ammonium (NH₄⁺), nitrate (NO₃⁻), organic matter (OM), total nitrogen (TN), total phosphorus (TP), bacterial diversity and community composition, potential functions of rhizome roots, and soil microbiota across a chronosequence of intensively managed Moso bamboo (*Phyllostachys edulis*) forests. Our results demonstrated that the combined intensive managements (deep tillage, fertilization, and organic material mulching) in this study caused a significant increase in the concentrations of AK, AN, AP, NH₄⁺, NO₃⁻, OM, TN, and TP ($P < 0.05$). However, they led to a remarkable decrease in pH ($P < 0.05$). Such changes lowered the Shannon diversity of the soil and rhizome root microbiota but did not significantly affect the community composition and functional capacity. Soil bacterial community variation was predominantly mediated by soil total potassium (TK) (15.02%), followed by pH (11.29%) and AK (11.13%). We further observed that *Nitrospirae* accounted for approximately 50% of the variation in soil pH, NO₃⁻, NH₄⁺, and AK, indicating its importance in soil nutrient cycling, especially nitrogen cycling. Accordingly, we propose that the management-induced changes in soil parameters reshaped the bacterial community structure and keystone bacterial assemblage, leading to the differentiation of microbial functions.

Keywords: intensive management, *Nitrospirae*, soil chemical property, Moso bamboo, microbiota

Metabolic profiling and transcriptome analysis reveal the key role of flavonoids in internode coloration of *Phyllostachys violascens* cv. *Viridisulcata*

Hantian Wei^{1†}, Hou Dan^{1†}, Muhammad Furqan Ashraf^{1†}, Haiwen Lu¹, Juan Zhuo¹, Jialong Pei¹, Qixia Qian^{2*}

¹ State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University, Lin'an, Zhejiang, China

² College of Landscape Architecture, Zhejiang A&F University, Lin'an, Zhejiang, China

Qian023456@163.com (*Corresponding Author)

† These authors have contributed equally to this work and share first authorship.

Abstract: Bamboo, being an ornamental plant, has myriad aesthetic and economic significance. Particularly, *Phyllostachys violascens* cv. *Viridisulcata* contains an internode color phenotype in variation in green and yellow color between the sulcus and culm, respectively. This color variation is unique, but the underlying regulatory mechanism is still unknown. In this study, we used metabolomic and transcriptomic strategies to reveal the underlying mechanism of variation in internode color. A total of 81 metabolites were identified, and among those, prunin as a flavanone and rhoifolin as a flavone were discovered at a high level in the culm. We also found 424 differentially expressed genes and investigated three genes (*PvGL*, *PvUF7GT*, and *PvC12RT1*) that might be involved in prunin or rhoifolin biosynthesis. Their validation by qRT-PCR confirmed high transcript levels in the culm. The results revealed that *PvGL*, *PvUF7GT*, and *PvC12RT1* might promote the accumulation of prunin and rhoifolin which were responsible for the variation in internode color of *P. violascens*. Our study also provides a glimpse into phenotypic coloration and is also a valuable resource for future studies.

Keywords: bamboo, internode coloration, metabolic, transcriptome, flavonoids

Complete chloroplast genome features of *Dendrocalamus farinosus* and its comparison and evolutionary analysis with Other Bambusoideae species

Jialong Pei¹, Yong Wang², Juan Zhuo¹, Huibin Gao², Naresh Vasupalli¹, Dan Hou¹, Xinchun Lin^{1*}

¹ Zhejiang A&F University, Hangzhou, China
linxcx@163.com (*Corresponding Author)

² Yibin Forestry and Bamboo Industry Research Institute, Yibin, China

Abstract: *Dendrocalamus farinosus* is one of the essential bamboo species mainly used for food and timber in the southwestern region of China. In this study, the complete chloroplast (cp) genome of *D. farinosus* is sequenced, assembled, and the phylogenetic relationship analyzed. The cp genome has a circular and quadripartite structure, has a total length of 139,499

bp and contains 132 genes: 89 protein-coding genes, eight rRNAs and 35 tRNAs. The repeat analyses showed that three types of repeats (palindromic, forward and reverse) are present in the genome. A total of 51 simple sequence repeats are identified in the cp genome. The comparative analysis between different species belonging to *Dendrocalamus* revealed that although the cp genomes are conserved, many differences exist between the genomes. The analysis shows that the non-coding regions were more divergent than the coding regions, and the inverted repeat regions are more conserved than the single-copy regions. Moreover, these results also indicate that *rpoC2* may be used to distinguish between different bamboo species. Phylogenetic analysis results supported that *D. farinosus* was closely related to *D. latiflorus*. Furthermore, these bamboo species' geographical distribution and rhizome types indicate two evolutionary pathways: one is from the tropics to the alpine zone, and the other is from the tropics to the warm temperate zone. Our study will be helpful in the determination of the cp genome sequences of *D. farinosus*, and provides new molecular data to understand the Bambusoideae evolution.

Keywords: *Dendrocalamus farinosus*, *Bambusoideae*, *chloroplast genome*, *phylogenomics*

Overexpression of *PvSVP1*, an *SVP*-like gene of bamboo, causes early flowering and abnormal floral organs in *Arabidopsis* and rice

S.N. Liu^{1, 2}, D. Hou¹, N. Vasupalli¹, X.C. Lin^{1*}

¹ Zhejiang A&F University, Hangzhou, China
linxcx@163.com (*Corresponding Author)

² Guangxi University, Nanning, China

Abstract: Bamboo is a no-timber woody plant featuring a long vegetative stage and uncertain flowering time. Therefore, the genes belonging to flowering repressors might be essential in regulating the transition from vegetative to reproductive stage in bamboo. The *SHORT VEGETATIVE PHASE* (*SVP*) gene plays a pivotal role in floral transition and development. However, little is known about the bamboo *SVP* homologs. In this study, *Phyllostachys violascens PvSVP1* is isolated from analysis of the *P. edulis* transcriptome database. Phylogenetic analysis shows that *PvSVP1* is closely related to *OsMADS55* (rice *SVP* homolog). *PvSVP1* is ubiquitously expressed in various tissues, predominantly in vegetative tissues. To investigate the *PvSVP1* function, *PvSVP1* is overexpressed in *Arabidopsis* and rice under the influence of the 35S promoter. Overexpression of *PvSVP1* in *Arabidopsis* causes early flowering and produces abnormal petals and sepals. Quantitative real-time PCR reveals that overexpression in *Arabidopsis* produces an early flowering phenotype by downregulating *FLC* and upregulating *FT* and produces abnormal floral organs by upregulating *API*, *AP3* and *PI* genes. Simultaneously, overexpression of *PvSVP1* in rice alters the expression of flowering-related genes such as *Hd3a*, *RFT1*, *OsMADS56* and *Ghd7* and promotes flowering under field conditions. In addition, *PvSVP1* may be a nuclear protein and interacts with *PvVRN1* and *PvMADS56* on yeast-two hybrid and BiFC. Our study suggests that *PvSVP1* may play a vital role in the flowering time and development by interacting with *PvVRN1* and *PvMADS56* in the nucleus. Furthermore, this study paves a path toward understanding the complex flowering

process of bamboo.

Keywords: *Phyllostachys violascens*, *PvSVP1*, ectopic expression, flowering time, yeast-two hybrid and BiFC

Ectopic expression of a bamboo *SVP*-like gene alters flowering time and floral organs in *Arabidopsis thaliana*

S.N. Liu^{1,2}, N. Vasupalli², D. Hou², X. C. Lin^{2*}

¹ Guangxi University, Nanning, China

² Zhejiang A&F University, Hangzhou, China
linxcx@163.com (*Corresponding Author)

Abstract: The *Short Vegetative Phase (SVP)* gene is a key regulator for floral transition and development. Although *SVP*-like genes have been identified and characterized in many plant species, their orthologs in bamboo have not been characterized. In this study, one *SVP* homolog was isolated from lei bamboo based on the *P. edulis* transcriptome database and designated as *PvSVP2*. Phylogenetic analysis showed that *PvSVP2* was closely related to rice *OsMADS47*. Expression analysis revealed that *PvSVP2* was widely expressed in different tissues but significantly in vegetative tissues. Moreover, it has higher transcript levels in the late stages of flower development. Overexpression of *PvSVP2* in *Arabidopsis thaliana* caused the early flowering and abnormal floral morphologies. Further, the qRT-PCR analysis showed that the genes regulating flowering time (*FT* and *SOC1*) and flower development (*API*, *AP3* and *PI*) expressions significantly increased in transgenic *A. thaliana* lines and correlated with *PvSVP2* expression. The subcellular location of *PvSVP2* in both onion epidermal cells and *A. thaliana* protoplast was localized in the nucleus and cytomembrane. Through yeast two-hybrid and BIFC assays, we identified that *PvSVP2* interacts with *PvMADS56* (a *SOC1* homolog) and *PvVRNI* (an *AP1* homolog). These results suggested that *PvSVP2* may play an essential role in the flowering process of bamboo by regulating the *PvMADS56* and *PvVRNI*. Besides, we purified and obtained the *PvSVP2* recombinant protein by prokaryotic inducement. Our data will provide information to understand the characterization and function of *PvSVP2* and be beneficial to illustration the molecular mechanism of bamboo flowering.

Keywords: *Phyllostachys violascens*, *PvSVP2*, flowering time, ectopic expression, functional analysis

Genome-wide identification and evolution of WNK kinases in Bambusoideae and transcriptional profiling during abiotic stress in *Phyllostachys edulis*

Rongxiu Liu^{1†}, Naresh Vasupalli^{1†}, Dan Hou¹, Antony Stalin^{1,2}, Hantian Wei¹, Huicong

Zhang¹, Xinchun Lin^{1*}

¹ State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University,
Lin'an, China

² State Key Laboratory of Subtropical Silviculture, Department of Traditional Chinese
Medicine, Zhejiang A&F University, Lin'an, China
linxcx@163.com (*Corresponding Author)

† These authors have contributed equally to this work and share first authorship.

Abstract: With-no-lysine (WNK) kinases play vital roles in abiotic stress response, circadian rhythms, and regulation of flowering time in rice, *Arabidopsis*, and *Glycine max*. However, there are no previous reports of WNKs in the Bambusoideae, although genome sequences are available for diploid, tetraploid, and hexaploid bamboo species. In the present study, we identified 41 *WNK* genes in five bamboo species and analysed gene evolution, phylogenetic relationship, physical and chemical properties, cis-elements, and conserved motifs. We predicted the structure of *PeWNK* proteins of moso bamboo and determined the exposed, buried, structural and functional amino acids. Real-time qPCR analysis revealed that *PeWNK5*, *PeWNK7*, *PeWNK8*, and *PeWNK11* genes are involved in circadian rhythms. Analysis of gene expression of different organs at different developmental stages revealed that *PeWNK* genes are tissue specific. Analysis of various abiotic stress transcriptome data (drought, salt, SA, and ABA) revealed significant gene expression levels in all *PeWNKs* except *PeWNK11*. In particular, *PeWNK8* and *PeWNK9* were significantly down- and up-regulated, respectively, after abiotic stress treatment. A co-expression network of *PeWNK* genes also showed that *PeWNK2*, *PeWNK4*, *PeWNK7*, and *PeWNK8* were co-expressed with transcriptional regulators related to abiotic stress. In conclusion, our study identified the *PeWNKs* of moso bamboo involved in circadian rhythms and abiotic stress response. In addition, this study serves as a guide for future functional genomic studies of the WNK genes of the Bambusoideae.

Keywords: *WNK*, Moso bamboo, gene expression, abiotic stress

Homo- and hetero-dimers of CAD enzymes regulates lignification and abiotic stress response in Moso bamboo

Naresh Vasupalli¹, Hou Dan¹, Rahul Mohan Singh², Hantian Wei¹, Long-Hai Zou¹, Kim Yrjälä^{1,3}, Aimin Wu^{4,5}, Xinchun Lin^{1*}

¹ State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University, Lin'an, China
linxcx@163.com (*Corresponding Author)

² Shanghai Center for Plant Stress Biology, and CAS Center for Excellence in Molecular
Plant Sciences, Chinese Academy of Sciences, Shanghai, China

³ Department of Forest Sciences, University of Helsinki, Helsinki, Finland

⁴ Guangdong Key Laboratory for Innovative Development and Utilisation of Forest Plant
Germplasm, College of Forestry and Landscape Architecture, South China Agricultural
University, Guangzhou, China

⁵ *State Key Laboratory for Conservation and Utilisation of Subtropical Agro-bioresources, South China Agricultural University, Guangzhou, China*

Abstract: Lignin biosynthesis enzymes form complexes for metabolic channelling during lignification and these enzymes also play an essential role in biotic and abiotic stress response. Cinnamyl alcohol dehydrogenase (CAD) is a vital enzyme that catalyses the reduction of aldehydes to alcohols, which is the final step in the lignin biosynthesis pathway. In the present study, we identified 49 CAD enzymes in five Bambusoideae species and analysed their phylogenetic relationships and conserved domains. Expression analysis of Moso bamboo *PheCAD* genes revealed that *PheCAD2* has the highest expression level and is expressed in many tissues and *PheCAD1*, *PheCAD6*, *PheCAD8* and *PheCAD12* were also expressed in most of the tissues studied. Co-expression analysis identified that *PheCAD2* positively correlates with most lignin biosynthesis enzymes, indicating that *PheCAD2* might be the key enzyme involved in lignin biosynthesis. Further, more than 35% of the co-expressed genes with *PheCADs* were involved in biotic or abiotic stress responses. Abiotic stress transcriptomic data analysis identified that *PheCAD2*, *PheCAD3* and *PheCAD5* genes were highly upregulated, confirming their involvement in abiotic stress response. Through yeast two-hybrid analysis, we found that *PheCAD1*, *PheCAD2* and *PheCAD8* form homo-dimers. Interestingly, BiFC and pull-down experiments identified that these enzymes form both homo- and hetero- dimers. These data suggest that *PheCAD* genes are involved in abiotic stress response, and *PheCAD2* might be a key lignin biosynthesis pathway enzyme. Moreover, this is the first report to show that three *PheCAD* enzymes form complexes and that the formation of *PheCAD* homo- and hetero- dimers might be tissue specific.

Keywords: *Moso bamboo, CAD, yeast-two hybrid, BiFC, pull-down*

The important role of plant carbon sink capacity in sustainable development: its determination and model establishment of common plant species in Yangtze River Delta cities

Hu Yonghong

*Shanghai Chenshan Botanical Garden, Shanghai, China
huyonghong@csnbgsh.cn (Corresponding Author)*

Abstract: The ‘carbon peaking and carbon neutrality goals’ strategy which been incorporated into the overall layout of China's ecological civilization construction has become an important step to mitigate global warming and promote harmony between human and nature. The efficient and accurate measurement of plant carbon sink in urban heterogeneous environment is a big issue in afforestation and forestry work.

Aim to the problems of low remote sensing recognition rate of urban greening trees, lack of local carbon sequestration models, difficulties in traditional method for model and few suitable plant species of urbangreen space in the Yangtze River Delta region, the methods such as field survey, mathematical modeling, parameter deduction and remote sensing estimation has been studied to clarify the important role of plant carbon sequestration capacity in urban sustainable

development. The main results are as follows:

1) A self-driven remote sensing measurement system for carbon sequestration of urban heterogeneous green space which included the local allometric growth equations of "crown diameter-tridimensional green volume" and "crown diameter -biomass" of 16 common tree species has been established. So that the problems such as high crown overlapping, poor spectral separability of tree species and building shadow interference have been solved. 2) A nondestructive carbon sequestration calculation method and model of *Cinnamomum camphora* which based on tridimensional green volume and gas exchange was established. The actual values of net productivity, biomass and harvest method of *C. camphora* calculated by the theoretical value of photosynthesis were compared and verified. It was found that the net productivity and biomass by method of theoretical value of photosynthesis was 12.1% and 13.4% higher than actual values by traditional harvest. The calculation accuracy rate by theoretical model was 87.3 which was better than 80% of the model of Shenyang Institute, Chinese Academy of Sciences. 3) The differences of diurnal photosynthetic processes and light response curves of typical tree species in different seasons, weather conditions and light environments were clarified. The carbon sequestration capacity per unit leaf area and main adult individual plants of 215 tree species was quantified. Hence, a query system and database for high carbon sequestration plants with the largest number of plant species in China were established for providing a basis for plant carbon sequestration calculation and selection urban green space.

In conclusion, the methods, materials and technologies have been tested in the practice of parks and green spaces in the Yangtze River Delta cities such as Shanghai, Hangzhou and Hefei city. It will provide technical support for the design, construction and maintenance of urban green spaces with high carbon sinks. And it also will achieve the rapid and accurate carbon sequestration measurement and technological leaps in increasing carbon sinks and reducing emissions in green spaces.

Keywords: *carbon neutrality, remote sensing identification of tree species, tridimensional green volume, high carbon sequestration plants, light response curve*

Implication of rhizome systems of bamboos for growth mode, clonal structure and evolution of flowering behavior

A. Makita

*Akita Prefectural University, Akita, Japan
makita@akita-pu.ac.jp (Corresponding Author)*

Abstract: The rhizome system is a basic component which determine the ecological features of bamboos in various aspects. In this presentation, I will show the implication of rhizome systems from the three aspects, based on the long-term study of mainly on the regeneration process after mass flowering.

The topics I refer are as follows: 1) difference in the growth traits and the mechanism of culm density regulation in seedling populations between the species with different rhizome system,

2) the clonal structures which determine the genet interminglement, caused by rhizome systems, and 3) joint-evolutionary hypothesis between the rhizome system and the flowering behavior, from tropical bamboos with clump forming pachymorph rhizome system to temperate ones with horizontal leptomorph rhizomes, with special reference to genet interminglements.

Keywords: *rhizome system, flowering behavior, genet interminglement, leptomorph rhizome, pachymorph rhizome*

Distribution patterns and aboveground net primary productivity of bamboos in northern Laos

Singkone Xayalath

*Forestry Research Center, National Agriculture and Forestry Research Institute, Laos
singkone75@gmail.com*

Abstract: The study has demonstrated to the usefulness of biogeographical quantification of wild bamboos, which are difficult to distinguish from planted ones. The environmental were identified as elevation and temperature factors significantly correlated with the distributions of wild bamboo species. The purposes of this research are to investigate the distribution patterns and aboveground net primary productivity of bamboos in northern Laos. This based on the results of this research on bamboo inventory in northern Laos, the taxonomic information was organized which indicated that the bamboo species were found 63 in the Northern parts of Laos. The allometric equations will help in developing future work on carbon stocks and cycles in bamboo forests in this region. The AGB and aboveground NPP in five common bamboo species was calculated using monthly measurements collected over a year. Bamboos in this region may have marked carbon sequestration capabilities. The area of northern Laos: 112,805 km², there are 47.6% of total areas. In northern Laos the fallow forest cover with: 34.8% (1-3yrs), 19.6% (fallow >4yrs). Which bamboo forest cover total culm density (/ha): 5833 (fallow 1-3yrs), 13580 (fallow >4yrs), and culm DBH (cm): 2.55 (fallow 1-3yrs), 3.18 (fallow >4yrs). With carbon content: 50% of biomass, Litterfall (Mg/ha/yr): 4.77; and culm mortality and recruitment rate (%/yr): 3.67 and 17.62. These high aboveground NPP estimates and sympatric distribution of multiple bamboo species indicate that bamboos have an important role in sequestering carbon in the region. This research suggested that the basic requirement, species, classification of bamboos are needed for the further studies.

Keywords: *bamboo diversity, carbon sequestration, allometric equations, fallow forest*

Physiological integration of carbon and its dynamic response to drought stress on moso bamboo plantation

Xiaogai Ge^{1,2*}, Benzhi Zhou¹

¹ *Research Institute of Subtropical Forestry, Chinese Academy of Forestry, Hangzhou, Zhejiang, China*

*gexiaogai2006@163.com (*Corresponding Author)*

² *Qianjiangyuan Forest Ecosystem Research Station, State Forestry Administration of China, Hangzhou, Zhejiang, China*

Abstract: Drought would significantly influence the forest soils through changing new carbon allocation, the litterfall production and decomposition process. Bet hedging is a strategy of trees fighting drought by storing active carbon at the expense of growth to decrease the risk of death. It is extremely important for ecosystem stability and the decrease of tree death to understand carbon allocation priority and carbon transfer times as affected by drought. However, comprehensive *in situ* studies on drought effects in subtropical forests, especially in bamboo forests, have rarely been conducted. Here, we conducted a throughfall exclusion experiment with a rainfall reduction of ~80% in moso bamboo (*Phyllostachys edulis*) forests to investigate effects of drought on litter quantity, quality, soil microbial and enzyme activities, soil nutrients and new carbon allocation across two years in subtropical China. Drought decreased recently C assimilation by 30.9%-53.4% in leaves, but did not change the residence time of different tissues. While it come up to the soil after labelling 15d, moso bamboo allocated more recent assimilate carbon belowground under drought condition (by 11.38% and 8.07% in 0-15cm and 15-30cm), which indicate a strategy of maintaining osmotic potential and function of rhizome and root. We observed that drought treatment significantly decreased soil moisture by 63% compared to ambient control treatment. Drought significantly decreased the annual litterfall in the second treatment year, and the leaf litter decomposition rate (-30% relative to CK) over 2 years of decomposition. Structural equation modelling revealed that drought decreased the contribution of litter quantity to soil nutrients but increased that of litter quality and soil microbial community to soil nutrients. Our results suggest that increasing drought events in subtropical China will directly reduce litterfall quantity and quality on the one hand, alter the soil enzyme activities and microbial composition on the other hand, all of which will consequently decrease litter decomposition rate, soil nutrient availability, growth rate and productivity, leading to changes in the functioning and services of subtropical bamboo forests.

Keywords: *through exclusion, carbon integration, isotope labeling, source-sink relationships, soil carbon*

Coupling of human settlement and biological diversity: practice and thinking of cultural landscape conservation

Xiaowei Huo

THUPDI, Beijing, China

Abstract: According to the time-honored philosophy of ‘harmony between people and nature’, cultural landscape is of great importance for the form of environment in China both in history and at present, as it reflects the connotation of human settlement and biodiversity. Taking the example of the ancient tea plantation of Jingmai Mountain in Pu’er City of Yunnan Province, and the White Crane Town in Poyang Lake in Nanchang City of Jiangxi Province, this presentation introduces the practice and thinking of combing the improvement of living conditions and biodiversity restoration in the field of cultural heritage conservation and the high-quality development of urban-rural environment.

Keywords: *cultural landscape, biological diversity, human settlement*

Unraveling impacts of climate change on ecosystem function of bamboo forest

Junwei Luan¹, Yi Wang¹, Xipin Wu¹, Xiaomin Gao², Shirong Liu²

¹ *Institute of Resources and Environment, Key Laboratory of Bamboo and Rattan Science and Technology of State Forestry and Grassland Administration, International Centre for Bamboo and Rattan, Beijing, China*

² *Key Laboratory of Forest Ecology and Environment of National Forestry and Grassland Administration, Ecology and Nature Conservation Institute, Chinese Academy of Forestry, Beijing, China*

Abstract: Forest ecosystems globally have either been previously impacted by drought or are expected to experience drought. Simultaneously, the deposition of N from the atmosphere to forests has increased from 15 million tonnes per year in the 1860s to 187 million tonnes by 2005 and is expected to continue to increase. Moso bamboo (*Phyllostachys heterocycla*) represents an important forest type in China and covering 4.9 million hectares. Here we conducted a two-factor environmental change manipulative experiment in a typical Moso bamboo forest in southwest China. A full factorial block design comprising manipulation of throughfall (ambient vs. throughfall reduction, hereafter called drought) and N (control vs. N addition) was established in May 2017, with four treatments randomly distributed in each of the four blocks. We then investigated important ecosystem processes that reflecting ecosystem carbon sequestration capacity, including soil respiration, litter decomposition, sap flow of bamboo culms. We revealed that drought significantly reduced ecosystem processes, and found that adding nitrogen to this N-enriched forest could alleviate drought effects on foliar water state and growth of Moso bamboo through altered stomatal sensitivity, hydraulic architecture, and photosynthesis, but exacerbate the decelerated decomposition as a result of reduced soil water condition. Our findings provide insights for a better prediction of ecosystem processes and functioning under projected global environmental change conditions.

Keywords: *bamboo, climate change, carbon cycling, drought, ecosystem function*

Thematic Area 2.

Green Industry and Economic Recovery





Building resilience in Terai Arc Landscape through community managed rattan forests

Chhote Lal Chowdhary

*Biodiversity Conservation Center Nepal (BCCN), Ratnanagar, Nepal
clchowdhary2006@gmail.com*

Abstract: After managing natural rattan in the community forests about 25 years, lowland ecology has been restored that provides ecosystem services, adaptive capacity of community people, and enrichment of biodiversity corridor and strengthen community based institutions in the long term. Among the nine species of rattan found in Nepal, *Calamus tenuis* is the major rattan species found in more than 20 Community Forests of Bardiya and Kailali districts. The rattan forests are distributed in Terai Arc Landscape (TAL). TAL is a largest landscape level initiative supporting the government for enriching biodiversity corridor and protected area, conservation of flagship through participatory management that compose 14 Indian and Nepalese trans-border protected ecosystem of the Terai and near by the foothills of the Himalaya. Buffer Zone Management User Groups and Community Forest User Groups are grass root level institutions managing forests including biodiversity through participation of community people. Although rattan is native to this area, role on biodiversity of rattan is one of the unattended aspects of Nepalese rattan. Although economic importance was major concerns a decade ago, community people also value this species for enrichment of biodiversity and restoration of degraded forest ecology. Gradually, in-situ conservation of rattans has drawn attention of people's participation, managing forests, environment and genetic conservation. Rattan forest are considered biodiversity rich habitat.

Keywords: *resilience, ecosystem services, biodiversity, landscape, community forestry*

The revitalization of traditional bamboo handicraft industry and the sustainable development of ecological economy

Xie Tao^{1}, Li Quan²*

*¹ Huanggang Normal University, Huanggang, China
xietao@hgnu.edu.cn (*Corresponding Author)*

² Hubei Engineering University, Xiaogan, China

Abstract: With rapid changes in science and technology, culture and lifestyles, bamboo handicrafts have been giving way to industrial products, leaving little room for their survival and development. In addition, there is a shortage of successors to bamboo product masters. As a result, bamboo handicraft culture is going into irreversible decay. However, under the background of the Rural Revitalization Strategy in the New Era, the inheritance of excellent traditional culture and the revitalization strategy of traditional crafts are strengthened and promoted. Local governments, village-based organizations, related societal organizations and

bamboo handicraft practitioners promote the inheritance and innovative development of traditional bamboo handicrafts in various forms as a whole, and jointly boost the dynamic inheritance of diversified values of the bamboo handicraft industry and the sustainable development of the ecological economy. It has been proven that designing can play a central driving role in its revitalization. Therefore, through creative designing empowerment and bamboo cultural industrialization, we can stimulate the cultural consciousness and cultural self-confidence of different stakeholders, actively explore the incentive effects of bamboo handicraft industrialization on regional economy in rural areas, and transform the resource advantages of handicrafts into cultural soft power of rural revitalization and internal development momentum.

Keywords: *traditional bamboo wares, bamboo handicrafts, industrial revitalization, design empowerment, ecological economy*

The construction of Yunnan ethnic minority bamboo cultural characteristic villages from the perspective of One Village One Product (OVOP)

Hui Yu^{1}, Hui Chaomao²*

*¹ College of Arts and Sciences Kunming, Kunming, China
352692712@qq.com (*Corresponding Author)*

² Southwest Forestry University, Kunming, China

Abstract: Although the development of the "One Village One Product" (OVOP) economy started later in Yunnan than in other developed provinces, its space and potential is huge. In addition to the abundant regional resources of animals and plants, in Yunnan, there are many unique ethnic cultures. Among them, the bamboo culture of ethnic minorities is a kind of characteristic resources with important development value. This paper aims to construct an OVOP mode for ethnic minority villages in Yunnan province, so that the bamboo cultural villages constructed under this mode can meet not only the requirements of OVOP in terms of economic driving, but also the functions of exploring, inheriting and protecting ethnic minority characteristic cultures.

The construction of this model combines the in-depth development of the characteristic bamboo culture industry, the development of the minority tourism, the green economic development of the minority rural areas, the construction of the minority cultural brand and other themes, which is of great significance for the further development of tourism in the minority areas of Yunnan Province and the improvement of the economic and cultural level. It both play to the advantages of traditional *OVOP* (namely the revitalization of the local economy, eliminate the gap between the rich and the poor and the gap between urban and rural areas), and implementation of new value (that is, to protect, inherit and carry forward Yunnan minority characteristic culture), and realize the sustainable development of ecological environment and national culture.

Keywords: *One Village One Product (OVOP), ethnic minority bamboo culture, characteristic villages*

The commercialization of timber bamboo in Nepal. A SWOT AHP analysis

A. Kafle^{1}, L. Binfield², S.K. Paudel³*

¹ *Tribhuvan University, Institute of Forestry, Pokhara, Nepal
kafleapsana@gmail.com (*Corresponding Author)*

² *University of British Columbia, Vancouver, Canada*

³ *United Nations Environment Program, Vientiane, Lao PDR*

Abstract: Naturally distributed across the ecological regions, bamboo is a culturally and ecologically important plant in Nepal. They have been used historically as a source of food and traditional handicrafts. The development of bamboo as a structural alternative to wood timber through commercialization is relatively recent, both globally and in Nepal. Adequate research and technological advancement in the Nepalese bamboo sector is lacking and bamboo sector here is relatively primitive. In order to access the present status of timber bamboo commercialization in Nepal, this study uses the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis combined with a multicriteria decision making technique called Analytic Hierarchy Process (AHP). The method was adopted to identify and study the relevant factors required for the successful commercialization of bamboo in Nepal from multi stakeholder perspective. Our findings suggest *employment supported by the local value chain, poor market, and marketing infrastructure, growing research and development interest, and uncertainty in product delivery and quality* to be the most important SWOT factors. Similarly, the positive factors viz. strength and opportunities outweighed the weakness and challenges. The highest ranked factor was growing research and development interest that reveals the prospect of slow transition of bamboo sector from subsistence use to commercialization. The paper further diagnoses the implications of the overall SWOT results.

Keywords: *AHP, commercialization, timber, SWOT*

Research on the redesign method of traditional bamboo furniture in western Hunan province

Xiao Derong

*College of Furniture and Art Design, Central South University of Forestry and Technology,
Changsha, China
2991900010@qq.com*

Abstract: Traditional bamboo furniture in Western Hunan Province has rich ethnic flavor and regional characteristics, and it is a historical witness and material carrier of the integrated

development progress of multiple ethnic groups in this region. The paper systematically reviews the existing types of traditional bamboo furniture in Western Hunan and taps the cultural genes embedded in the furniture. On this basis, it constructs a model for redesigning traditional bamboo furniture in Western Hunan and proposes the specific approaches for the redesigning that meets the needs of modern life so as to develop a batch of original bamboo furniture of Western Hunan characteristics and also diversify the existing types of bamboo furniture, which is aimed to make traditional bamboo furniture in Western Hunan play a greater role in the local rural revitalization.

Keywords: *Western Hunan Province, traditional bamboo furniture, redesign, methods*

Futuristic approach with bamboo products for grass root people enhancement with climate action

Yogesh Y. Sumthane^{1}, Sanjeev Kumar¹, G. Rawale²*

¹ *Banda University of Agriculture and Technology Banda, Uttar Pradesh, India*
(*Corresponding Author)

² *Chaudhary Charan Singh Haryana Agricultural University, Hisar, India*

Abstract: The major purpose of Bamboo products is to inspire, initiate, design, and implement sustainable development processes based on eco-fraternity. We are as a government organization whose mission is to empower rural people by delivering long term solutions to improve rural and tribal livelihoods. Livelihood support program striving to ensure regular work days and income for members of producer groups. The beneficiary of our livelihood support program is rural women and rural youth from impoverished backgrounds. Our Department of Forest products believes that women's economic empowerment would essentially strengthen their voices, which in turn would contribute to the root cause of gender equality and also overall growth and development by providing them with exposure and self-belief to change and challenge their lives. Our experiments and explorations in the Bamboo industry are equally fuelled by the environmental benefits of the most important nature's substitutes for the endangered forest hardwoods. It is a quick-growing, versatile, non-timber forest product whose rate of biomass generation is unsurpassed by any other plants. It spread to other locations by virtue of multifarious uses. It absorbs more carbon dioxide and release more oxygen than any other plant species and is an effective erosion control plant. Bamboo waste generated by making bamboo products can be used in electricity generation through gasification process. Bamboo products like handicraft and Furniture have an immense potential to generate income and provide wealth to grass roots. It is an ultimate substitute for wood, plastic, and iron. With the great pleasure of bamboo species diversity, its strength and flexibility, slenderness and girth, hollowness and wall thickness, local adaptability and universality, bamboo remains a material being explored forever. Help of our technology transformation and knowledge sharing perspective Bamboo products help to provide wealth to villagers and tribal people with respect to climate action.

Keywords: *bamboo, livelihood, grass root, wealth, climate action*

Study on the law of nutrient requirement and control technology of *Neosinocalamus affinis*

Jiarui Li, Chao Peng, Xizhen Liu, Guanglu Liu*, Shaohui Fan*

Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, International Centre for Bamboo and Rattan, Beijing, China

* Corresponding authors: liuguanglu@icbr.ac.cn (G.L.); fansh@icbr.ac.cn (S.F.)

Abstract: Nutrient management plays an important role in the sustainable management of *Neosinocalamus affinis* plantation which is dual-purpose bamboo in culm and shoot. To explore the supply of main soil nutrient elements and law of nutrient requirement of *N. affinis*, the correlation between soil and nutrient elements in leaves of *N. affinis* was discussed. The main limiting factors of *N. affinis* growth were analyzed and tested. Results: (1) The eight soil factors of pH, organic matter, total N, total P, total K, hydrolyzed N, available P and rapidly available K had different degrees of correlation with the contents of N, P, K and organic carbon of leaf. Among them, soil pH was great significantly positively correlated with leaf N and P content, and soil hydrolyzed N was significantly positively correlated with that, while the other relevance was not significant. (2) A total of 78 plots were set up to apply N, P and K fertilizers with different application rate. When the soil total phosphorus content is 0.11-0.14 g·kg⁻¹, *N. affinis* has higher reproductive rate and productivity, and the same is true when the soil available phosphorus content is 1.80-1.90 mg·kg⁻¹. Conclusion: The soil pH value and soil P content had a great influence on the nutrient content of *N. affinis* leaves, and the P content of leaves could be used as a reference index for the nutritional diagnosis of *N. affinis*. The application of N, P and K fertilizers can effectively improve the productivity of bamboo forest. The recommended nitrogen fertilizer for *N. affinis* is 181.25-191.67 kg·hm⁻², the phosphate fertilizer is 10.05 kg·hm⁻², and the potassium fertilizer is 32.25-49.00 kg·hm⁻².

Keywords: *Neosinocalamus affinis*, soil fertility, productivity, nutrient management

Zhejiang Anji bamboo industry machinery and equipment development status and policy measures

Huang Hongliang

Anji County Forestry Bureau, Huzhou, China
324007360@qq.com

Abstract: In recent years, with the shortage of labor, the rise of labor costs, and the lag in the development and promotion of related machinery and equipment, bamboo production costs remain high. In addition, the price of bamboo raw materials has fallen sharply, which leads to lower and lower benefits of bamboo forest management. There are nearly 180,000 mu of bamboo forest lost and abandoned in Anji County. The sustainable development of bamboo industry and ecological problems of bamboo forest are becoming increasingly prominent. According to the investigation, in the process of forest management, the links of bamboo

exploration, hook, material gathering and loading have been inorganic for a long time. The penetration rate of bamboo saws used in moso bamboo cutting is low because of poor applicability. The mechanization rate can reach about 70% only in the link of care, cutting and irrigation. In the primary processing links such as bamboo and wool, the independent operation of each mechanical equipment requires manual connection and empirical production, which has not yet achieved continuous, intelligent and efficient production. In order to accelerate the whole process of bamboo industry mechanization, this year Anji County issued special policies and measures: first, strengthen the research and development of bamboo machinery and equipment, arrange 2.6 million financial funds for new technology, new equipment research and development, constantly fill up the development of weak points; Second, promote the purchase and use of bamboo machinery and equipment, and give subsidies to the forest machinery equipment purchased by the business entity, the amount of subsidy is 50% of the purchase price; Third, to speed up the construction of social service organizations, to the registered forestry professional team, to give social insurance, personal accident injury insurance subsidies; Fourthly, strengthen the typical demonstration, establish the innovation test base of the management and preliminary processing machinery and equipment of the show bamboo, and play an exemplary and leading role; Fifth, improve the basic conditions of bamboo forest production and management, increase road repair in forest areas, lay a good foundation for the entry and operation of machinery and equipment.

Keywords: *Moso bamboo, forests, in raw, machinery and equipment*

Circular economy concept

Rowen Meda

Mutenga Bamboo, Zimbabwe

Abstract: Mutenga Renewable & Sustainable Bamboo Circular Economy Concept is a concept founded by one of the local residents of Nzvimbo Village in Chiweshe who saw the need to contribute positively to the rural community as well as coming up with strategies towards promoting and eco-friendly environment. The above concept mainly focuses on mitigating the effects of climate change, starting with the community in Chiweshe. Climate change is a threat to the food and water security, human health, social, economic and political stability of the Chiweshe rural community. The founder of the above concept has taken a leadership role with regards to changing the mindset of the Chiweshe locality pertaining to use of alternative energy sources whilst maintain environmentally friendly activities. This novel concept utilizes the magic plant ‘Bamboo’ in the transformation of the environment and also as a solution to most of the rural problems in a renewable and sustainable way following the circular economy concept. Creating bamboo forests is one of enhancing oxygen production. Bamboo also acts as a carbon sink, controls soil erosion, regulates water levels, and conserves biodiversity. This has ignited a bamboo revolution, starting with changing the Chiweshe community towards the repairing and restoring the decapitated rural environment, then moving outward to other rural communities in Zimbabwe thus bringing out a compounded effort in saving our environment from the effects of climate change. The availability of locally produced bamboo products

contribute in the reduction of Zimbabwe's import bill, revitalisation the local manufacturing industries as well as creation of rural employment. In order to implement the above concept, Mutenga Bamboo Private Limited Company was formed serving as a link between the environment and its community, towards the move for environmental preservation, biodiversity protection, forestry restoration and rural industrialization, all of which to mitigate the effects of climate change. Climate change, according to the Zimbabwe's National Climate Change Response Strategy (NCCRS) is the biggest threat to humanity today and Zimbabwe is not exempt as it is already experiencing environmental degradation, water shortages, poverty, hunger and inequality. In Zimbabwe climate change has caused temperatures to rise by 3°C, this has contributed to the decline of rainfall in most of its regions due to global warming as evidenced by a decline in the average rainfall in Zimbabwe by 10% or 100mm in the past 100 years. Mutenga Bamboo (Pvt) Ltd also introduced contract farming of bamboo to farmers in Chiweshe and surrounding areas in Mashonaland Central Province. Bamboo farming and production of bamboo related products will play a pivotal role as a catalyst in attaining the 17 Sustainable Development Goals (SDGs) to transform communities in Chiweshe and Zimbabwe as a nation. The concept that Mutenga Bamboo is riding on gives and supports the ability to be incorporated in tandem with the renewable and sustainable energy micro grid that utilizes the bamboo waste, the construction of biogas plants, and also an effective litter disposal system for the community hence promoting the 17 Sustainable Development Goals enshrined in the UN SDGs. Bamboo offers the best opportunity for investors worldwide to be offered equity through the establishment of rural factories for the manufacturing of different eco-friendly and degradable products. The bamboo roots network is effective for soil erosion, landslide control, and rainwater retention. A bamboo forest can be strategically planted on a riverbank or lakeshore for the stabilization of the soil. In addition, Mutenga Bamboo (Pvt) Ltd adds value to the bamboo in different ways to the market creating a self-sustainable cyclic value chain. Mutenga Bamboo (Pvt) Ltd concept also encourages a conservation policy that supports forestry and wildlife preservation, providing an opportunity for every ward or village in Zimbabwe to have a piece of natural forestry that grows naturally or with little management. In the case of Nzvimbo Village in Chiweshe, there is the underutilized Nzvimbo dam, unexplored Gonhi Mountains (historically known to have been the battle field for the 2nd Chimurenga), the magnificent Cheuchi Mountain, the memorable Chombira Mountain (which has a history of being the fort for the BSAP), the outstanding Zimani Mountain, marvellous Gombekombe Mountains, sacred Bare Mountain, fascinating Banje Mountain, and the famous spiritual Nyota Mountain. This creates an excellent opportunity of rural tourism being birthed given that the conservation policy is implemented successfully, with wild animals introduced in the resident ecosystem.

Keywords: *land degradation, deforestation, unemployment, pollution*

Study on the promotion system of bamboo forest therapy and cultural-tourism

B.Y. Lv, H.Y. Lai, Y. Meng, X.X. Zhang, M.Y. Jiang, Q.B. Chen*

Sichuan Agricultural University, Chengdu, China

Abstract: Under the background of "Beautiful China" and "Healthy China", bamboo forest therapy and cultural-tourism makes full use of the efficient ecological benefits and environmental advantages of bamboo forest, and provides a good combination and entry point for promoting the construction of ecological civilization. Otherwise, the combination mode of bamboo forest and small town integrates bamboo industry with cultural and tourism industry, links primary, secondary and tertiary industries, accelerates the modernization of bamboo industry, drives local economic development and cultural dissemination, improves rural quality, advocates healthy and low-carbon living, and contributes to rural revitalization.

The promotion of different bamboo forest therapy and cultural-tourism, shall abide by the people-oriented, adjust measures to local conditions, functional diversity, ecological principle such as the priority, guarantee the different bamboo town retain local characteristics, meet the demand of different people, combined with tourism, leisure, health care, entertainment experience variety of ways, promote the development of its diverse and comprehensive. Therefore, this paper conducts research on three successful bamboo forest towns: Hejiang Fubao Scenic Spot, Qionglai Pingle Town and Chongzhou Daoming bamboo village. According to its product characteristics, content and promotion characteristics are summarized, in order to sum up different industrial promotion modes, to provide a basis for the practical application of bamboo forest town cultural tourism healing project promotion, and to provide theoretical support for the system construction.

Keywords: *healthy living, bamboo town, bamboo forest town cultural tourism healing project promotion, rural revitalization*

The current situation of bamboo resource cultivation and the potential for increasing production in China

Zheng Shihui¹, Liu Guanglu^{1,2}

¹ *International Centre for Bamboo and Rattan, Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China*

² *Fujian Yong'an Bamboo Forest Ecosystem Positioning Observation and Research Station, Yong'an, China*

Abstract: In order to make full use of China's rich bamboo resources to help farmers reduce poverty, a study on the current situation of bamboo resources cultivation and yield increase potential in China was carried out by applying literature research and questionnaire surveys in important bamboo producing areas. The main situation: (1) About 60 species of bamboo have been studied in China, accounting for about 10% of the total number of bamboo species in China, and mainly focused on the research about moso bamboo, and the research papers about moso bamboo accounted for about 21% of the total research papers. (2) The survey found that in operating bamboo forests, 72.41% of the counties (cities) had bamboo forest revenue \leq 400 yuan, and low yield and inefficient forests accounted for a higher percentage; through

calculation and analysis, when the profit per mu was 400-800 yuan, the bamboo forest operation was more efficient. (3) Literature research shows that management can significantly improve bamboo forest productivity (17-800%), which can increase bamboo biomass by 55.99 million tons per year according to the 17% yield increase effect, with great potential for new bamboo resources. It is recommended to actively expand the research and utilization of characteristic bamboo germplasm, improve the high quality and efficient cultivation of bamboo forests and the management level of new bamboo forests to enhance the supply level of bamboo resources in China and better support the healthy development of bamboo industry.

Keywords: *bamboo resources, bamboo species research, bamboo forest management, utilization potential, production potential*

Study on cutting methods of Moso bamboo

Guofu Wang¹, Wei Zhang^{1}, Min Ji¹, Xingliang Diao¹, Hu Miao^{1,2}*

¹ *Research Institute of wood Industry, Chinese Academy of Forestry, Beijing, China
1028229449@qq.com*

² *International Centre for Bamboo and Rattan, Beijing, China*

Abstract: Bamboo is widely used in construction, transportation, furniture and other excellent engineering materials. Moso bamboo cutting operation still has the problems of low mechanization level, low efficiency, serious waste, and mechanical equipment and bamboo harvesting technology has not formed a good integration. In this paper, the cutting process of bamboo vertical sawing and truncation in forest was theoretically analyzed, and based on ABAQUS software, the important influencing factors of bamboo sawing process and the formation mechanism of the surface quality of the processed surface were obtained. Based on the principle of orthogonal experiment, the optimized cutting methods of reciprocating saw and chainsaw were obtained and the cutting effects of the two methods were compared. The cutting surface quality of the reciprocating saw is better, and the cutting efficiency of the chainsaw is higher. This study can guide the actual production of bamboo cutting and provide conditions for the whole process mechanization of bamboo processing.

Keywords: *Moso bamboo, cutting, finite element, mechanical analysis, field test*

Research progress on wood quality of Moso bamboo under different cultivation measures

Liyang Liu

*International Centre for Bamboo and Rattan, Beijing, China
1109655463@qq.com*

Abstract: The research on bamboo properties in China is usually based on processing utilization or mutation law, but the research on the fresh bamboo properties and cultivation is related. This paper gives a comprehensive overview of the research on the wood quality of hairy bamboo under different cultivation measures. The effects of fertilization, intermediate cuttings, irrigation and other cultivation measures and site conditions on the anatomical properties, chemical properties, physical and mechanical properties of Moso bamboo were systematically summarized. It is concluded that the better the site condition is, the worse the wood quality of bamboo is. Long-term fertilization is not suitable for timber forest, and three years old bamboo is the best one for timber forest cutting. So as to provide suggestions for the cultivation of timber forest.

Keywords: *Moso bamboo, cultivation measures, material quality, site conditions*

Can phylogenetic studies aid ecological restoration of *Calamus* species in India?

Kurian A.¹, Muralidharan E.M.²

¹ *Biotechnology Department, SCMS School of Technology and Management, Kochi, India*

² *Department of Biotechnology, Kerala Forest Research Institute, Thrissur, India
emmurali@gmail.com*

Abstract: In India, *Calamus* is the only genus of rattans distributed in all the three major biogeographical zones viz. Peninsular India, North-east and Andaman and Nicobar Islands and is the only rattan genus predominantly distributed in evergreen, semi-evergreen and moist deciduous forests of India. The rattan resources in all three zones are under threat of genetic erosion due to habitat loss, fragmentation and conservation strategies will depend on the understanding of the phylogenetic process at play and speciation. Phylogenetic studies were carried out to determine the evolutionary process of the highly specious genus *Calamus* using six gene regions to help to restore the *Calamus* species after better understanding of relationship between them. Phylogenetic analysis for the individual data matrix and combined data sets were conducted by Bayesian Inference using programme Mr Bayes. This study analysed the importance of both morphological as well as molecular characters for resolving the phylogenetic relationship between the *Calamus* species. The results of the phylogenetic analysis showed that *Calamus* species of Western Ghats using morphology and molecular data does not support it as a separate geographical entity because North Eastern species as well as species from Andaman and Nicobar Islands nested together with it. The present study concludes that, the *Calamus* species of the three zones are closely related and share similar functional traits and thus similar ecological niches. Hence building corridors between different biogeographic zones is needed to increase the evolutionary potential by allowing for increased gene flow between populations.

Keywords: *rattan, Western Ghats, restoration, phylogeny, monophyly*

Investigation on culm form characteristics of *Phyllostachys edulis* ‘Yuanbao’

Yuan Jinling¹, Yue Jinjun¹, Ma Jinxia², Yu Lei¹, Liu Lei^{3*}

¹ Research Institute of Subtropical Forestry, Chinese Academy of Forestry,
Hangzhou, China

² Anji Bamboo Exposition Garden Co. Ltd., Anji, China

³ Research Institute of Forestry, CAF, Beijing, China
liulei519@caf.ac.cn (*Corresponding Author)

Abstract: The paper aims to conduct quantitative analysis on the culm form characteristics of *Phyllostachys edulis* ‘Yuanbao’, thus to provide a basis for its further study and development. We established a set of quantitatively measurement and analysis approaches for *Ph. edulis* ‘Yuanbao’, and the bamboo individuals planted in Huanggongwang Forestry Garden which locates in Fuyang District, Hangzhou, Zhejiang, China were tested through these approaches. The results showed that the average height and diameter of *Ph. edulis* ‘Yuanbao’ were 5.0 m and 7.09 cm, respectively, which equaled to 34.25% and 70.34% of *Ph. edulis* under approximately ecological situations. The nodal number for the lowest branching was genetically stable under different ecological environments. At an internodal number range from 1st to 30th, the average internodal length of *Ph. edulis* ‘Yuanbao’ increased along with the internodal number, and it reached 11.06 cm at the 30th internode, which amount to 36.87% of *Ph. edulis* at the same internodal number. The adjacent internodes skewed to each other in culms of *Ph. edulis* ‘Yuanbao’, namely, the length of the same internode varied at different directions, and the internodal length at the two branching sites were the longest and the shortest alternatively, while the internodal length in its vertical sites changed subtly with both values close to the average. Internodal skew length at base and upper part in culms of *Ph. edulis* ‘Yuanbao’ were short, while it’s long at middle culms in 9th to 14th internodes. The average internodal diameter decreased along with the internodal number at the internodal number range from 1st to 30th. The internodes usually double-side concaved, the concave depth was low at the base part, and it raised along with the promotion of internodal number, reaching the deepest at 10th to 23rd, and then declined along with the internodal number ascending. In other words, the 1st to 2nd internodes concaved slightly at the branching sides, and there was an internodal site with no cave between 2nd and 3rd internodes, then the concave directions rotated after this site, and the subsequent internodes concaved at the directions vertical to branching, namely, the 3rd to 30th internodes concaved at the sides vertical to branching, with the deepest depth in internodes from 10th to 23rd. Except 1st and 2nd internodes, the upper half had a wider diameter than the lower half in each internode for 3rd to 30th for their lower part’s concave. The culms of *Ph. edulis* ‘Yuanbao’ were oblate rounded, and the 1st and 2nd internodes were near round with subtly oblate at direction vertical to branching, and the oblate rounded index in upper half larger than lower half in each internode; the oblate direction rotated at a site between 2nd and 3rd internodes; the 3rd to 30th internodes were oblate at branching direction with oblate rounded index in upper half smaller than lower half in each internode. The culm’s oblate index enhances gradually from 3rd to 15th internodes, reaching high at 15th to 23rd internodes, and declined gradually from 23rd to 30th internodes, reached nearly round at the 30th internode. Rubbing and photo profiles showed waving nodes in culms of *Ph. edulis* ‘Yuanbao’. This article set a protocol for the measurement and analysis for a distinctive

bamboo culm form in *Ph. edulis* ‘Yuanbao’, which also providing a supplement for the approaches on bamboo’s culm study. Though this study, we obtained the quantitative information on the internodal length, internodal skew length, internodal diameter, internodal concave depth, internodal oblate index of *Ph. edulis* ‘Yuanbao’. We also elucidated the variation patterns of adjacent internodal skew, the internodal concave and the oblate characteristics in the whole culm of *Ph. edulis* ‘Yuanbao’. And we discovered that the internodal concave direction and the culm oblate direction rotated once at a site between 2nd to 3rd internodes of *Ph. edulis* ‘Yuanbao’. This information provided a whole profile for the understanding of culm form in *Ph. edulis* ‘Yuanbao’, which also supply a hint for the culm form study of other distinctive bamboos.

Keywords: *Phyllostachys edulis* ‘Yuanbao’, culm form characteristics, quantitative analysis, internodal length, internodal diameter

The dynamics of non-structural carbohydrates in different types of bamboo in response to their phenological variations: implications for managing bamboo plantations

H. Zhan^{1,3,4}, W. He^{3,4}, M. Li², L. Yu^{3,4}, J. Li^{3,4}, C. Wang^{1,3,4}, S. Wang^{3,4*}

¹ College of Forestry, Southwest Forestry University, Kunming, China

² Yunnan Academy of Biodiversity/College of Biodiversity and Conservation, Southwest Forestry University, Kunming, China

³ Key Laboratory for Sympodial Bamboo Research, Southwest Forestry University, Kunming, China

⁴ Science and Technology Innovation Team of National Forestry and Grassland Administration, Southwest Forestry University, Kunming, China
stevenwang1979@126.com (*Corresponding Author)

Abstract: Non-structural carbohydrate (NSC) dynamics in different bamboo types underlie the different management practices of bamboo plantations. The changes in moisture, soluble sugars, and starch content in response to phenological variations in different types of bamboo were measured to reveal the NSC dynamics in different bamboo forests for high yield. It was reported for the first time that new leaves of monopodial bamboo started sprouting after the completion of branching, while sympodial bamboo extended new leaves and branches simultaneously. NSC accumulation for shooting lasted about eight months for monopodial bamboo but only a short interval of two to three months for sympodial bamboo. The moisture content in different types of bamboo showed a similar trend of increasing from March to July and then decreasing until the coming January. From March to May, particularly in March, irrigation was required for the shooting of monopodial bamboo, whereas the shoot buds in sympodial bamboo showed sprouting, branching, and leafing. Total NSCs in different bamboo types remained relatively high in March, gradually decreased to the lowest in July, and then increased continuously until the coming January. Average soluble sugar and starch contents showed the same trend as the total NSCs in different types of bamboo. During the period from March to July, large amount of photoassimilates were required for shooting and height growth

and then for branching and leafing in monopodial bamboo. Abundant photoassimilates were also required for branching, leafing, and shoot bud differentiation, as well as for subsequent shoot germination in sympodial bamboo. Thus, fertilizer application to both monopodial and sympodial bamboo plantations should be scheduled in early May and late July. Given the moisture, soluble sugar, starch, and total NSC content, January was the best season for harvesting monopodial bamboo for high production and future growth, whereas for sympodial bamboo, November was the best season.

Keywords: *phenological variation, non-structural carbohydrates, sympodial bamboo, monopodial bamboo, management practices*

Sustainable bamboo product life cycle design management strategy

Xue Yun¹, Khairul Aidil Azlin Abd Rahman^{1}, Zhang Fankai², Cao Xiaobing³*

*¹ University Putra Malaysia, Kuala Lumpur, Malaysia
gs57564@student.upm.edu.my*

² Baise Development and Reform Commission, Baise, China

*³ Zhejiang A&F University, Hangzhou, China
drkhairulazlin@upm.edu.my (*Corresponding author)*

Abstract: The development and manufacture of products and the consumption of materials have led to a large loss of natural resources. This development trend has led companies to start to pay attention to the re-understanding of the product life cycle. One of the core issues of the product production process is how to realize the product life cycle management by considering the life cycle management. Overall value creation throughout the life cycle. This paper firstly summarizes the current status of bamboo products, and according to the research questions put forward, adopts the questionnaire survey method to conduct empirical research, measures the satisfaction of bamboo products, and constructs a bamboo product evaluation including 4 dimensions and 22 indicators. Index system, using SPSS for statistical analysis of bamboo product satisfaction. The research results show that bamboo products need to be improved in green design, production technology, material improvement and brand cultural expression. Based on this, this paper will evaluate the results of the questionnaire in combination with the theoretical model of product life cycle, propose improvement strategies, and urge the redesign of the life cycle model in the development of bamboo products, so as to promote the development of people's sustainable life and the establishment of social green consumption values.

Keywords: *bamboo product, satisfaction, life cycle design, management strategy*

Economic analysis of sustainable bamboo cultivation strategy for *Dendrocalamus stocksii* across different treatment regimes in semiarid regions of India

Sruthi Subbana¹, Lubina P. A.², Syam Viswanath³

¹ *Bamboo Society of India, India*

² *World Bamboo Foundation, KSCSTE-Kerala Forest Research Institute, India*

³ *KSCSTE-Kerala Forest Research Institute, Trichur, Kerala, India*

sruthisubbanna@gmail.com

Abstract: Sustainable and Climate-smart agriculture is essential in a country like India, where agriculture is a gamble especially due to erratic rainfalls. Bamboo is a potential economic species that can be utilized for mitigation of poverty alleviation and climate change helping achieve Sustainable Development Goals 1 and 13. Studies have pointed out that dryland dependent populations as the most ecologically, socially, and politically marginalized, lagging behind on most economic and health indices and that climate change creates additional stress in a vulnerable system.

Cultivation of bamboo has been existence since long in India which has expanded further since the availability of micropropagated plantlets. With increase in cultivation, it is also essential to enhance crop harvest through different treatment methods. In this study we have elaborated our findings on productivity of different treatment methods; viz. T0-NPK, T1-Biochar, T2-Biochar compost, T3-NPK+Biochar, T4-NPK+Biochar compost, T5-control for *Dendrocalamus stocksii*. A detailed financial and economic cost benefit analysis was also done including the Benefit to Cost (B/C) Ratio, Net Present Value (NPV), Internal Rate of Return (IRR) and Equated Annual Income (EAI). While results indicate a positive ratio of over 1.0 across all the scenarios, it was found to be most beneficial in the case of T1 at 4.48 followed by T3 at 4.13. Other economic parameters were also economically beneficial. The study also highlights the need for research across other species to facilitate better bamboo growth enhancing its carbon sequestration potential while also translating to better financial returns for the farmer enabling poverty alleviation.

Keywords: *Dendrocalamus stocksii, bamboo, economic analysis, benefit to cost ratio, biochar*

Mechanical properties and fatigue properties of twisted plant fiber reinforced polyurethane composites

Li Wenting, Li Mingpeng, Chen Jihe, Yuan Zhitong, Cheng Haitao

International Centre for Bamboo and Rattan, Beijing, China

lwt7519530@163.com

Abstract: With the expanding global demand for environment-friendly and resource recycling, the use of plant fibers as reinforcement for composite materials and the development of high-performance, high-value-added and versatile products have become important directions for

the green and ecological development of composite materials. Flexible polyurethane foam (FPUF) has excellent performance and wide application, but under long-term static compression, viscoelastic behavior such as creep will occur, leading to performance failure and a series of problems such as loss of hardness, insufficient support, and collapse and deformation. The use of twisted vegetable fiber (TPF) as reinforcement implanted in FPUF can achieve targeted local enhancement of mechanical strength and fatigue properties.

The twisted plant fiber/flexible polyurethane foam composite (TPF/FPUF) was prepared by multi-dimensional reinforcement implantation. The effects of reinforcement orientation, hairiness and volume fraction of twisted fibers on the interfacial bonding, mechanical properties, and fatigue resistance of TPF/FPUF were investigated. The results showed that the mechanical properties and fatigue resistance of the composites were improved after reinforcement, the interfacial bonding of transverse reinforcement was better than that of longitudinal reinforcement, and the interfacial bonding of twisted fibers with less hairiness and polyurethane was better. For the mechanical properties, the indentation hardness was increased by 89.69% at the highest; the support coefficient was generally increased by 37.98% up to 3.56, and the support performance was improved; the hysteresis loss rate was generally reduced in transverse samples, and the comfort when used as matting material was improved, and the cushioning performance was generally increased in longitudinal samples. For fatigue resistance, creep resistance is improved, and the deformation is smaller after long time use; 40% hardness loss is reduced by 38.59%, and in order to maintain the same hardness, the maximum number of cycles after grafting can reach 4.1 times of the blank sample; compression permanent deformation is reduced by 29.63% compared with the blank sample after grafting.

Keywords: *plant fiber, stiffeners, flexible polyurethane foam, composites, mechanical properties*

Effects of alkali treatment on properties of bamboo strips and their composites

*Chen Jihe, Gu Shaohua, Li Wenting, Yuan Zhitong, Cheng Haitao**

*International Centre for Bamboo and Rattan, Beijing, China
18800466928@163.com*

Abstract: With the strategic goals of "carbon peak" and "carbon neutralization" put forward in China, the development of green, low-carbon, light and high-strength composite materials has become an inevitable trend. The bamboo strip has the characteristics of refinement, homogenization and standardization, so as to develop cost-effective bamboo strip composite materials with low energy consumption and high utilization rate. However, the interface compatibility between polar hydroxyl groups on the surface of bamboo strips and non-polar resin matrix is poor. Alkali solution is used to treat bamboo strips to promote the penetration of resin on the interface and improve the mechanical properties of composite materials.

In order to study the effect of NaOH alkali treatment concentration on the properties of bamboo strips and its epoxy resin composites, the composites with an average content of 75% bamboo

strips were prepared by hot pressing. By setting four concentration gradients of NaOH solution, the properties of the materials were characterized by means of SEM, thermal analysis TG and DMA. NaOH alkali treatment removed some substances on the surface of bamboo strips, changed its polarity, increased its crystallinity from 60.0% to 63.6%, and enhanced its tensile strength and thermal stability; When the concentration of NaOH solution was 2 wt%, the tensile strength of bamboo strips increased by 52.11%, and the shear strength of its composites increased by 146.8%; At the same time, the bamboo strip / epoxy resin composite (BS / EP) treated with NaOH alkali has better structural stability under dynamic load at 30 ~ 90 °C, and the maximum storage modulus of the composite treated with 2 wt% NaOH solution is 1.3 times that of the untreated. The results show that alkali treatment can enhance the thermal stability, tensile strength of bamboo strips and the interface strength between bamboo strips and epoxy resin, improve the static and dynamic mechanics of bamboo strips reinforced epoxy resin composite, and provide a theoretical basis for bamboo strips composite to partially replace glass fiber composite

Keywords: *bamboo strips, Alkali treatment, composite material, mechanical properties, interface properties*

Bamboo-based green economic development of Rongmei community

L. Panmei, T. Selvan

*Department of Forestry and Biodiversity, Tripura University, Tripura, India
lungailupanmei20@gmail.com*

Abstract: Bamboo is inherent in the livelihood and sociocultural outlook of multitudinous ethnic populaces around the world. The Rongmei community is an ethnic minority of North-East India suffering from poor financial and infrastructural facilities. Data was collected through semi-structured questionnaires, farm visits and observations along with market survey. Two commercially important bamboo species viz. *Dendrocalamus hamiltonii* and *Melocanna baccifera* are naturally distributed throughout their home districts of Tamenglong and Noney, Manipur, India. In recent years farmers who practiced subsistence *Jhum* (shifting-agriculture) has reclaimed such lands by commercial plantation of bamboo especially *Bambusa tulda*; other species includes *Bambusa nutans*, *Bambusa variostrata* and *Thyrostachys oliveri*. Total revenue in 2022 from 20 *B. tulda* farms till the date of this write-up stands at 9,69,000 INR of which 5,19,000 INR was from selling poles and 4,50,000 INR from selling shoots during May-July. While, such farms also employ labour for cutting of poles and harvesting of shoots. Wild bamboo shoots collectors earn an average 50,000 INR per year by selling shoots of *D. hamiltonii* to fermenters and *M. baccifera* to vegetable vendors. Net estimated investment by 5 fermenting enterprises is 45,00,000 INR. On the other hand, the RNBA Development, a non-profit NGO working among the Rongmei has conducted skill development and entrepreneurship trainings since the last three years producing about 200 skilled workers specialised in furniture and crafts from bamboo and rattan; many of which has become self-employed. Consequently, bamboo and rattan can be a source of green economic empowerment for the community.

Keywords: livelihood, commercial plantation, entrepreneurs, skill development, economic empowerment

Graded variations in ultrastructure and topochemistry of rattan cane (*Calamus simplicifolius*)

Jianfeng Ma, Shumin Yang, Genlin Tian, Lili Shang, Qianli Ma, Xing'e Liu*,
Zehui Jiang*

Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, International Centre for Bamboo and Rattan, Beijing, China

Abstract: Gaining a better understanding of macro- and microstructure of lignocellulosic fiber in a chemical sense is important to optimize its highly efficient utilization. Substantial differences in ultrastructure and topochemistry of response to radial position were observed as a function of anatomical fraction for rattan cane (*Calamus simplicifolius*). *In situ* corelative imaging techniques and wet chemistry approaches were used to investigate the anatomy, ultrastructure, topochemistry and chemical composition along the rattan cane. It was revealed that the rattan cane displayed the herbaceous anatomy features with characteristic vascular bundles surround by parenchyma and multilayered fiber, while it has *Salicaceae* trees like lignin and hemicelluloses composition. With regarding to the chemical composition of the lignin, the signals from aromatic region suggest that the rattan lignin is composed of syringyl (S, δ_C/δ_H 103.3/6.7), guaiacyl (G, δ_C/δ_H 110.6/6.9), and *p*-hydroxyphenyl (H, δ_C/δ_H 127.8/7.2) units. The ratio of S to G is 4.29 and 2.70 for rattan bark (RB) and core (RC), respectively. The alkali-extractable hemicelluloses had a structure composed of the (β -1-4)-Xylp backbone with 4-O-Me- α -D glucuronic acid attached to O-2, giving a ratio of X/U of 23 and 20 for RB and RC, respectively. The above results will deepen our understanding of cell wall biosynthesis of rattan. Also, the information on the ultrastructure and chemical composition will provide theoretical instruction for the protection of micro-mechanical failure of rattan cane and optimization of rattan cane modification.

Keywords: *Calamus simplicifolius*, ultrastructure, topochemistry, microscopic imaging, NMR

Temporal and spatial characteristics of Moso bamboo (*Phyllostachys edulis*) forests under different strip clearcutting

Chu Haoyu, Su Wenhui, Fan Shaohui

International Centre for Bamboo and Rattan, Key Laboratory of Science and Technology of Bamboo and Rattan of State Forestry Administration, Anhui Taiping Bamboo Forest Ecosystem Observation Station, Beijing, China
swh612@icbr.ac.cn

Abstract: The study investigated the effects of different intensity strip cutting on shoot emergence and shoot development into new bamboo in Moso bamboo stands by setting four different bandwidth strip cutting treatments (3m, 6m, 9m, 12m) and using traditional selective logging as a control. The results showed that: (1) Compared with the control, strip cutting promoted the emergence of spring shoots, and the number of degraded shoots and new bamboos was the greatest in the 9m strips, but the cutting led to a reduction in DBH of new bamboos, and the size of DBH in new bamboos was related to the width of the strip;(2) Similar to the control, the number of shoots, degraded shoots, and new bamboos in the second week of the period when spring shoots germinate in different strips were the greatest and showed a trend of increasing and then decreasing with time; in addition, the rate of degraded shoots increased with time and the opposite is true for the rate of shoots grown into new bamboos; (3) The spatial distribution pattern of spring shoots and new bamboos was correlated with the study scale and the DBH of new bamboos in the 9m and 12m strip near the strip boundary. was larger than other areas. Strip cutting did not change the timing of spring shoot germination in Moso bamboo forests, but it did affect the quality of spring shoots and new bamboo, the spatial distribution characteristics of spring shoots and new bamboo are influenced by environmental factors and the physiological characteristics of the Moso bamboo.

Keywords: strip clearcutting, growing of shoot, time characteristics, spatial distribution

Ecological stoichiometric characteristics of soil carbon, nitrogen and phosphorus in *Chimonobambusa utilis* forest in Yiliang County

Zhong Huan¹, Dong Wenyuan^{1*}, Huang Wei², Wu Yiyuan³

¹ Southwest Forestry University, Kunming, China
2750756687@qq.com

² Nanjing Forestry University, Nanjing, China

³ Weixin County Forestry and Grassland Bureau, Weixin, China

Abstract: In order to understand the distribution pattern and stoichiometric characteristics of C, N and P in the *Chimonobambusa utilis* forest ecosystems in Yiliang County. Taking the soil of the young and mature *C. utilis* forest in Yiliang County as the research object, the content and stoichiometric characteristics of C, N and P in the *C. utilis* bamboo forest soil were determined and analyzed. The results showed that: (1) In the two stand types, soil C, N and P contents decreased with the increase of soil depth. The variation ranges of soil C, N and P contents in each soil layer of the two types of bamboo forests were 21.99-54.09, 2.39-5.67, 1.66-2.36g/kg, respectively. (2) The soil C/N, C/P, N/P of the young forest of *C. utilis* and the soil C/P and N/P of the mature forest decreased with the increase of soil depth, while the soil C/N ratio of the mature fores increased with the increase of soil depth. The soil C/N, C/P and N/P of the two types of bamboo forests were lower than the average levels of soil C/N, C/P and N/P in my country.(3)There are extremely significant positive correlations between soil C and N or N/P, between N and C/P, and between P and C/N in the two types of bamboo forests. The correlation between soil C and P and between N and P did not reach a significant level. The soil C and N elements in the young and mature *C. utilis* forest in Yiliang County have the

phenomenon of surface aggregation, and the soil organic matter and N contents are relatively low, and the stand growth is obviously limited by N. In the future bamboo forest management, nitrogen fertilizer can be appropriately increased.

Keywords: *Chimonobambusa utilis*, soil, stoichiometric ratio, Yiliang

Optimization of heat treatment process for *Calamus simplicifolius* by response surface methodology

Minmin Xu, Xing'e Liu

International Centre for Bamboo and Rattan, Beijing, China

Abstract: In this paper, the response surface methodology would be used to optimize the heat treatment process of *Calamus simplicifolius*. The main method was to heat-trench the vines with single-factor analysis. The heat treatment time, temperature and pressure were used as factors, and the impact toughness after heat treatment was used as the evaluation index. On this basis, the response surface methodology was used to optimize the heat treatment process. The result after treatment was that the heat treatment time, temperature and pressure had a significant impact on the impact toughness. According to the analysis results, it could be confirmed that the optimal treatment conditions were the pressure of 0.1MPa, the time of 0.5h, and the temperature of 160°C. The impact toughness under these conditions was 52.96. KJ/m². Through the above analysis, it can be concluded that heat treatment can improve the impact toughness of single-leaf vine, and the response surface method could effectively optimize the optimal heat treatment process.

Keywords: *Calamus simplicifolius*, response surface method, heat treatment, impact toughness

Variation of *Phyllostachys propinqua* leaf C, N, and P stoichiometry in Beijing-Tianjin-Hebei urban agglomeration

Chen Lei¹, Feng Yun¹, Zhu Lin¹, Pei Nancai², Sun Bing², Huang Biao¹, Li Xiaohua^{1}*

¹ *International Centre for Bamboo and Rattan, Beijing, China*

² *Research Institute of Tropical Forestry, Chinese Academy of Forestry, Guangzhou, China*

*xiaohua@icbr.ac.cn (*Corresponding Author)*

Abstract: In order to study the leaf stoichiometry characteristics of *Phyllostachys propinqua*, and to explore their correlation with environmental factors in winter, the study measured leaf carbon (C), nitrogen(N) and phosphorus(P) stoichiometry among 42 *Phyllostachys propinqua* in 7 cities from the Beijing-Tianjin-Hebei urban agglomeration. The results showed that there

were significant differences in C, N, P, C/N, C/P, and N/P of *Phyllostachys propinqua* leaf among different cities. The Shijiazhuang city leaf sample had the highest N content which reached to 21.67 ± 1.98 mg g⁻¹, while the Xingtai city leaf sample had the highest P content, which reached to 0.91 ± 0.22 mg g⁻¹. The leaf N and C/N, N and N/P, P and C/P, P and N/P were significantly correlated. Meanwhile, environmental factors, such as latitude, low temperature in winter and light have significant effect in leaf N, P stoichiometry. The latitude and light time was significant negative correlated to the leaf N, P stoichiometry, but winter temperature was significant positive correlated. This also shows that the environment, especially low temperature and light, are the key factors affecting the stoichiometry of *Phyllostachys propinqua* leaf in different cities.

Keywords: *Phyllostachys propinqua*, leaf stoichiometry, Beijing-Tianjin-Hebei urban agglomeration, environment factors.

Research and practice on the model construction of bamboo scenery line

X.X. Zhang, B.Y. Lv, Q.B. Chen*

Sichuan Agricultural University, Chengdu, China
cqb@sicau.edu.cn

Abstract: The cultivation and utilization of bamboo in China has a long history. Sichuan, the hometown of giant pandas, is rich in bamboo resources and has a good industrial foundation. In order to practice the concept of “Lucid waters and lush mountains are invaluable assets”, and implement the important instructions of General Secretary Xi Jinping “develop the bamboo industry according to local conditions and let the bamboo forest become a scenery line in Sichuan's beautiful countryside”, all Suitable for bamboodistricts in Sichuan Province earnestly implement the provincial guidelines. The provincial government has promoted the high-quality development of the bamboo industry, the deployment of the construction of beautiful countryside, the preparation of development plans from a high starting point, and the implementation of regional policies to promote the high-quality development of the bamboo industry. As a linear spatial form, the bamboo scenery line connects urban and rural spaces, interweaves and integrates diverse activities, and forms a unified network space system, which has powerful functions such as the circulation of biological elements and the integration of social resources. Starting with the origin and development of bamboo scenery line, this study expounds the definition of bamboo scenery line, summarizes the construction types and specific forms of bamboo scenery line, and clarifies the construction principles, evaluation system and identification standards of bamboo scenery line. Taking the content of bamboo scenery line construction in Yibin City as a typical case, this study fully shows the unique value of "consolidating bamboo ecology, promoting bamboo industry and excavating bamboo culture". Further outline the beautiful landscape ecological line, key industry demonstration line and living culture display line, put forward the bamboo scenery line construction model, benefit evaluation reference, to provide reference for all parts of the country.

Keywords: bamboo sceneric landscape, construction principles, evaluation system, typical case

Fabrication technologies of large-scale production of dimensional flattened bamboo lumber

Liu Huanrong, Huang Aiyue, Zong Yurong, Zhang Xiubiao, Fei Benhua

International Centre for bamboo and Rattan, Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China

Abstract: Compared with the modernized industries automation, such as agriculture, steel, plastics, bamboo engineering material manufacture is still in infancy. The most important reason is lacking of standardized units and standardized processing due to the variety of bamboo size and performance. Therefore, large-scale production of bamboo materials is difficult. In this study, the flattened bamboo plate without groove prepared by moso bamboo is used as research object. Grading, symmetrical and balanced structured, and high-frequency hot pressing process were studied to develop dimensional bamboo flattened composite lumber which would be intermediate unit for large-scale production. Results indicated that the high-frequency hot pressing is an efficient process for dimensional bamboo lumber. Its efficiency is 48 times of usual cold pressing. The optimized process parameters were: glue coating volume is 180 g/m², heating time is 110 s with 180 s keeping pressing, and positive pressure is 2.5 MPa. In this procedure, the mechanical properties of the dimensional bamboo flattening composite lumber are: MOR 125.1MPa, MOE 11.89GPa, compressive strength 65.2MPa, tensile strength 18.9MPa, shear strength of the rubber layer 10.0MPa, and thickness swelling rate of 24h cold water absorption 0.5%. Its physical and mechanical properties are higher than standard requirements of the structural bamboo and wood composite materials. Dimensional bamboo flattened composite lumber, with the advantages of cross-section size in standardization, serialization, stable performance, convenient transportation, can be intermediate unit to laminated bamboo engineering lumber large-scale production, and as bamboo integrated materials for floor, furniture and other products.

“Bamboo & Garden & Art” —— Practice of bamboo and rattan garden in the 10th China Flower Expo

Biao Huang, Hongming Peng, Yayun Deng, Yufei Meng*

*Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, International Centre for Bamboo and Rattan, Beijing, China
huangbiao@icbr.ac.cn (*Corresponding Author)*

Abstract: Based on the realistic background of global green change, how to sublimate from plant to plant landscape to artistic aesthetics, from bamboo materials to its material application to material aesthetic interpretation, is worth thinking and exploring in the field of contemporary landscape planning and application. Taking the presentation of scientific and artistic innovation in the bamboo and rattan garden of the 10th China Flower Expo in Chongming Island, Shanghai, China as an example, this paper tries to practice the fusion of scientific ecological

art and culture of "Bamboo & Garden & Art", in order to provide reference thinking for promoting the sustainable development of the global bamboo and rattan flower industry.

Keywords: bamboo and rattan garden, Bamboo & Garden & Art

Extending the utilization of bamboo, promoting "the Bamboo as a Substitute for Plastic Initiative"---an analysis of R&D and production of bamboo in outdoor leisure products of Zhejiang Hengfeng Top Leisure Co. Ltd.

W. Yu^{1}, B. Feng², M. Sheng¹, B. Yang¹*

*¹ Zhejiang Hengfeng Top Leisure Co. Ltd., Huzhou, China
wen.yu@hengfeng-china.com (*Corresponding Author)*

² Zhejiang Eco-Culture Association, Hangzhou, China

Abstract: Due to the use of fossil-based resources and the increase in consumption and population, the world is facing an imminent resource problem. "The Bamboo as a Substitute for Plastic Initiative" provides a Chinese solution to boost environmental sustainability. Relying on its renewable, recyclable and degradable characteristics, bamboo is highly sustainable. Based on a leading bamboo industry, many research institutions and enterprises in China have begun to develop and produce bamboo products to replace of plastic products. To promote the transition towards a green economy, Zhejiang Hengfeng Top Leisure Co. Ltd., as a global leader in outdoor products industry, strives to implement "the Bamboo as a Substitute for Plastic Initiative". Bamboo pulp products are used in packaging and laminated bamboo and bamboo scrimber, in collaboration with leading bamboo enterprises, are applied to outdoor leisure products, which are sold both on domestic and foreign markets. Hengfeng introduces the bamboo industry to a new field, strengthens the industry chain through the secondary to primary industries, which leads to increases of income for both the enterprise and local farmers. Based on the action of "the Bamboo as a Substitute for Plastic Initiative" promoted by Zhejiang Hengfeng Top Leisure Co. Ltd., this paper describes the progress and paths of the industrialization of the bamboo industry in a new sustainable field.

Keywords: the Bamboo as a Substitute for Plastic Initiative, outdoor leisure products, green economy, sustainable development

Ecological culture leads the realization path of "Substituting Bamboo for Plastic"

Ren Zhong

Zhejiang A&F University, Hangzhou, China

Abstract: Ecological culture is a cultural system that aims to pursue harmonious coexistence between people, people and nature, and people and society, and the highest value orientation of human society. It is mainly reflected in the change from the culture in which people ruled and conquered nature in the past to the culture of respecting nature and seeking the harmonious development of man and nature, with purpose which is to lead the harmonious development of economy and society. Anji County, Zhejiang Province is the birthplace of the concept of "two mountains". "Green water and green mountains are golden mountains and silver mountains" is a vivid interpretation of the essence of ecological culture, reflecting the organic unity of culture between the natural environment and the sustainable development of economy and society, which is an important part of the thought of the socialist ecological civilization of Xi Jinping in the new era. In recent years, An Ji has put into practice the concept of the "August 8th Strategy" of the General Secretary, drawing a blueprint to the end, therefore many fields are in the forefront of the country in the construction of ecological civilization. In order to further improve the level of ecological civilization construction, Anji took the lead in achieving the provincial goals of "carbon neutrality" and "carbon peak", adhering to the guidance of ecological culture, and constantly enriches the practice of "replacing plastic with bamboo", forming the realization path of "replacing plastic with bamboo".

Keywords: *ecological culture, substituting bamboo for plastic, route, Anji*

Biodiversity, biogeography, conservation of bamboos and sustainable development in Southeast Asia

*D.Z. Li *, J.X. Liu*

Germplasm Bank of Wild Species, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China

*DZL@mail.kib.ac.cn (*Corresponding Author)*

Abstract: Bamboos are members of a large grass subfamily Bambusoideae, including ca. 1,700 species of 136 genera in three tribes, i.e., Arundinarieae (temperate woody bamboos), Bambuseae (tropical woody bamboos) and Olyreae (herbaceous bamboos). With ca. 1,000 species in 75 genera, Bambuseae comprise the largest bamboo tribe, which can be further divided into paleotropical woody bamboos (PWBs) and neotropical woody bamboos. The PWBs are unevenly distributed across tropical and subtropical regions of Asia, Africa and Oceania, with two centers for diversification, Southeast Asia and Madagascar. As a unique hexaploid clade, the PWBs share a distinct evolutionary history and include the world's largest bamboo, the succulent bamboo, a number of climbing bamboos and those with flesh fruits. In the past decades, because of habitat destruction, many bamboo species are endangered or threatened, in turn affecting the fauna and microbiota associated with bamboo forests.

As fast-growing non-timber forest products, woody bamboos have long been used by indigenous people in Asia, Africa, Oceania and Latin America, playing vital roles in their daily life. Bamboo forests can serve as carbon sink, with a mean annual net carbon sequestration in

both trees and soil of some 6mg C per hectare, and can be continuously harvested for shoots, furniture, and flooring. Integrating bamboos into national, regional and local development plans is pivotal for biodiversity conservation and sustainability in Southeast Asian countries.

Keywords: *woody bamboos, taxonomy, distribution, endangered species, development plans*

The implementation path of green finance to meet carbon goals

Mengmeng Guo

Southwestern University of Finance and Economics, Chengdu, China

gmm@swufe.edu.cn (Corresponding Author)

Abstract: Climate change is already affecting the entire world, with extreme weather conditions such as drought, heat waves, heavy rains, floods and landslides becoming more frequent. The Chinese government promises to peak carbon dioxide emissions by 2030 and strives to achieve carbon neutralization by 2060. To achieve the double carbon target, green finance is a crucial financial tool. Hence, this paper mainly discusses how green finance contributes to the realization of the dual carbon target and the role of coping with climate change. We first introduce the development status of green finance. This paper further discusses the damaging impacts of climate change on economics as well as society. We separately explore the detrimental effects on enterprises, such as increasing their operational cost. Moreover, this paper will address the harmful effect on households as well. We further propose potential paths for the development of green finance, such as to stimulate enterprises to improve their ESG performance, to encourage financial sectors to issue related financial instruments. A case study related to green industry development is introduced to support the role of green finance in sustainable development. We provide meaningful policy suggestions on the development of green finance as well as enterprises' development strategies in the end.

Keywords: *green finance, climate change, ESG, green industry*

Nature based solutions for greener and climate resilient world: an interdisciplinary and scale perspectives from mountain ecosystem

N. Chettri

International Centre for Integrated Mountain Development, Kathmandu, Nepal

nakul.chettri@icimod.org (Corresponding Author)

Abstract: Over the past twenty years, an increasing number of perspectives have reflected an anthropocentric view of the management of natural capital with a focus on the benefits that nature provide for humans. One recent perspective is 'Nature-Based Solutions' (NbS), a concept introduced specifically to promote nature as a means for providing solutions to wider range of environmental, economic, and societal challenges. Now NbS has gained increased scientific and development focus to respond to climate crisis and promote adaptation and build resilience. Key idea was that NbS had potential to generate climate, biodiversity, and

sustainable development co-benefits. Despite its necessity, integration of natural and social sciences to inform conservation and development efforts has been difficult and challenging, especially in the mountain perspectives. This is largely due to silo and sectoral approach, with decision makers and practitioners not recognizing the intricate relationship between people, nature, and services. An integrative and transdisciplinary approach with strong emphasis on gender and inclusive NbS considering larger landscapes in a transboundary context is vital for sustainable and inclusive solution outcomes. However, operational clarity on how NbS can be applied and how much investment it required for its field application for conservation and development is still required to be explored. The Hindu Kush Himalaya has numerous good practices in conservation and restoration of degraded habitat along with community development at scale. We present a few case studies to rationalize the implications of NbS for greener and climate resilient world emphasizing on multidisciplinary and scale perspectives.

Keywords: *climate, natural capital, resilience, scale, ecosystems, Hindu Kush Himalaya*

Biodiversity and food system transition outlook

P. Zhang¹, Y. Zhang², P. Li², Y. Hu², C. Zhu^{2}*

¹ PwC China, Shanghai, China

*² Beijing Representative Office, World Economic Forum, Beijing, China
Chunquan.Zhu@weforum.com (*Corresponding Author)*

Abstract: Biodiversity is vital to the well-functioning of food system while the reality is that food system is exacerbating biodiversity loss. This study is dedicated to systematically elaborating the impact of food system on biodiversity by linking food system and the five direct drivers of biodiversity loss identified by IPBES in 2019. This study further concludes the *four faults* hidden behind the current food system, which are (1) driving biodiversity loss, (2) causing degradation of ecological system on the production sites, (3) the inability to feed the global population properly, and (4) the failure to secure the livelihoods of vulnerable groups within the system. This study argues that the underlying cause of its failure is the absence of common goals among stakeholders and the lack of incentives and mechanisms to bring them together. In this regard, after a thorough examination of the global agenda on food system, sustainable development and biodiversity governance, three goals and 16 directions towards a sustainable food system transition are proposed, which is put forward in the hope of building consensus among governments, industries, businesses and other sectors, and accelerating the making of relevant policies or strategies onwards. Finally, it is demonstrated that inputs of policy, fund and technology are indispensable elements for every successful transition of food system. In this way, this study summarizes keys points and opportunities for each element and advocates that all stakeholders should take actions timely and jointly in order to embrace a sustainable food system.

Keywords: *biodiversity, food system, climate change, sustainable development*

Close-to-nature agroforestry system for conservation and development in a globalized mountain region

Jianchu Xu^{1, 2}

¹ CIFOR-ICRAF, China Country Program, Beijing, China

² Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China
jxu@mail.kib.ac.cn (Corresponding Author)

Abstract: Agroforestry, a domain in the primary sector, is the only industry recognized to be of high carbon sequestration potential. It serves the dual function of carbon reduction and carbon sequestration, and thus occupies an important position in achieving the national target of carbon neutrality. The agroforestry carbon neutrality project proposed herein is a comprehensive project aimed to significantly enhance carbon emission reduction and carbon sequestration, as well as enhancing ecosystem services and further contributing to bioeconomy and human health.

Mountain Futures is a global initiative aimed at developing and sharing transformative solutions through close-to-nature agroforestry system and circular agriculture for sustainable futures for mountain peoples and ecosystems. It is based on dry-hot-valley of Honghe, Southwest Yunnan, aiming for global savannah region. We selected both landmark framework species such as baobab and cotton trees, as well as neglected species such as *Calotropis* spp and Alma (*Phyllanthus emblica*) for land restoration. We incorporated fungi, insect and livestock for nutrient cycles and bioeconomy development. We paid great efforts for market value chain development too.

Keywords: agroforestry, mountain futures, close-to-nature, circular agriculture, bioeconomy

The leaf phenotypic variation of the 12 bamboo species and their relationship with environmental factors

Yun Feng, Shaohui Fan, Guanglu Liu, Songpo Wei

International Centre for Bamboo and Rattan, Beijing, China

Abstract: To understand the characteristics of leaf phenotypic variation of different bamboo species and their adaptability to the environment, 12 bamboo species from Boai, Henan province, and Qingdao, Shandong province (introduced from Boai) were selected and their leaf phenotypic traits (leaf length, width, thickness, length/width, fresh weight, saturated fresh weight, and dry weight) were measured respectively. Then, the phenotypic variation and the principal component analysis of the 12 bamboo species in the two sites, the correlation between the leaf phenotypic traits and the environmental factors, and the allometric equations between the leaf phenotypic traits were analyzed. The results illustrated that there were no significant differences between the two sites for *Phyllostachys bissetii* and *Phyllostachys glauca* f. *yunzhu* when the bamboo species were introduced from Boai to Qingdao; there were one or several leaf phenotypic traits of the eight bamboo species of *Phyllostachys* significantly lower than

that in native habitat; there were several leaf phenotypic traits of *Pleioblastus chino* var. *hisauchii* and *Pseudosasa amabilis* var. *convexa* significantly higher than that in Boai. The phenotypic variation coefficients of leaf weight were higher than 20%, and the variation coefficient of leaf weight in Qingdao was higher than that in Boai. The principal component analysis based on the leaf phenotypic traits showed that the leaf weight can represent all the information of leaf phenotypic traits. There was a significantly positive correlation between the leaf thickness and temperature factors, and there was a significantly negative correlation between the leaf thickness and rainfall for all the species. The allometric analysis indicated that the growth rates of leaf thickness and leaf weight increased when species were introduced from Boai to Qingdao, and the growth rate of leaf weight was higher than that of leaf thickness. In total, the study revealed that compared with *Phyllostachys* species, *Pleioblastus chino* var. *hisauchii* and *Pseudosasa amabilis* var. *convexa* were more adaptable to Qingdao with decreased temperature but increased rainfall, and leaf weight was the main factor of leaf phenotypic traits, which could be used as an important evaluation index for cold tolerance.

Keywords: *bamboo, leaf phenotypic traits, variation coefficient, leaf weight, allometric growth*

Rattan – a sustainable material for plastic replacement

Wan Tarmeze Wan Ariffin

*Forest Research Institute Malaysia (FRIM), Kepong, Selangor, Malaysia
tarmeze@frim.gov.my*

Abstract: It is common these days to hear the statement that plastic is one of the main causes contributing to climate change and habitat degradation. However, we should not blame plastic entirely, instead we need to rethink how we should use this material optimally and manage its disposal without harming the environment. One of the ways is to ensure that the plastic products can last longer in the circular economy and that we have methods and technologies to dispose them more sustainably. Another way is by stopping to produce the plastic products that before this we did not even need plastic to make them. Such products, among them are items we all use in our homes: baskets, boxes and containers. Before plastic, most of these products were made using rattan (bamboo and wood too). Hence, why did we use plastic? We also need to change some of our habits of using products to become "less disposing and more reusing". Let us have a look at the following scenario. John Doe and family went for a beach vacation. On the way, they stopped at a petrol station to fill-up the gas tank. The wife went into the store and got themselves 12 bottles of mineral water. Some of the plastic bottles may have ended up in the ocean. How would rattan prevent this? A reusable glass bottle wrapped with rattan wickerwork and a 'scan your card here' mineral water dispenser might be able to give the answer.

Keywords: *rattan, sustainable disposal, plastic, circular economy, product usage habits*

Thematic Area 3.

Innovative Materials and Market Development





Chemical constituents analysis reveals the effect of artificial shading on reducing the bitter taste of bamboo shoots

*Hang Xun, Yongjian Huang, Feng Tang**

Key Laboratory of Bamboo and Rattan Science and Technology of the State Forestry Administration, Department of Bio-materials, International Centre for Bamboo and Rattan, Beijing, China

*fengtang@icbr.ac.cn (*Corresponding author)*

Abstract: Bamboo shoot is a delicious and nutritious forest vegetable. The edible shoots of many bamboo species are bitter tasting to some extents, and it has been found that bamboo shoots collected from low-light environments have a less bitter taste. The molecular mechanism of light in the regulation of bitter substance accumulation in bamboo shoots is still unclear. In this study, we applied a shading treatment to *Pleioblastus amarus* bamboo shoots in the preharvesting period. The reduction in the bitterness intensity was confirmed by a sensory test. An integrated metabolomic and transcriptomic analysis was performed on *P. amarus* bamboo shoots grown under shading treatment and normal growing conditions, and 56 differentially accumulated metabolites and 178 differentially expressed genes were identified. The results showed that the contents of a series of phenolic acids related to the tyrosine metabolism pathway were downregulated under shading treatment, revealing that shading decreased the accumulation of phenolic acids and further mediated the resulting bitter taste of the bamboo shoots. This work will be helpful for understanding the regulatory mechanisms governing the bitter tasting substances in bamboo shoots grown under a shading treatment and provides a reference for the use of shading treatment in cultivation practices to improve the taste of bamboo shoots.

Keywords: *bamboo shoots, shading treatment, bitter substance*

Bamboo-based wind turbine blade technology and its application prospect in bamboo industrialization

Zhang Wang, Du Yingzhuo, Lei Lei, Long Yujun, Andy Levers

TUS Bamboo Innovation Park Technology Co., Ltd., Yibin, China

Abstract: Bamboo has the characteristics of fast growth, high strength, wide distribution and green environmental protection. However, the high value-added application of bamboo on a global scale is still at a relatively early stage. The output of bamboo products is not only far less than that of metal and composite materials, but also not an order of magnitude compared to the output of wood. And its level of industrial automation is therefore at a lower level. Bamboo-based composite wind turbine blades represent the high technical level of today's industrial application of bamboo. This product opens a door for bamboo to be applied to more industrial-grade products by solving the problems of large discreteness, easy cracking and

deformation, and connection with metal materials. This paper expounds the key points and difficulties in the industrial application of bamboo from the aspects of bamboo discrete control, fatigue performance, connection design, integrated structure design and quality control. I hope to inspire the development of the global bamboo industry.

Keywords: *bamboo, industrialization of bamboo materials, bamboo-based composite materials, wind turbine blades*

Development of bamboo shaving reinforced concrete wall panel

Maria Cristina David

Pampanga State Agricultural University, Pampanga, Philippines

Abstract: This study deals with the experimental investigation of the effectiveness of bamboo shavings as reinforcement for concrete wall panel. The following materials were used to develop the bamboo-shaving reinforced concrete (BSRC) wall panel: bamboo shavings, which are wood-waste generated from agro-industries, Type I Portland cement, sand, gravel and tap water. Three different proportions of shavings were mixed with concrete, namely: 2%, 3%, and 4%, by weight.

Tests to determine the mechanical properties of the hardened mixture were made to identify the best formulated bamboo-shaving reinforced concrete (BSRC), particularly in terms of compressive and flexural strength. Further evaluation was made in terms of aesthetics and cost-effectiveness of the produced non-load bearing BSRC wall panel with dimensions 50 mm x 600 mm x 1,200 mm (2 in. x 2 ft. x 4 ft.) from the best formulated mixture. The test results indicated that, the developed BSRC wall panel possesses the desired properties of a low cost building material; thus, it can be utilized mainly for small-scale housing development for rural areas and small towns. The wall panel can be generally applied for non-load-bearing wall construction. This project can contribute towards solving both solid waste problem and house construction backlog.

Keywords: *bamboo shavings, reinforced concrete, mechanical properties, kawayan tinik*

Bamboo joint capacity determined by ISO 22156 ‘Complete Joint Testing’ provisions

K.A. Harries, C. Rogers, M. Brancaccio*

*University of Pittsburgh, Pittsburgh, USA
kharries@pitt.edu (*Corresponding author)*

Abstract: The newly promulgated ISO 22156:2021 enables the design of building structures

fabricated from full-culm bamboo. The ISO 22156 model code permits ‘complete joint testing’ as a means of directly determining bamboo joint design capacity and stiffness: “Design properties shall be established based on full-scale complete joint assemblages having the same geometry, fastener elements and details, and connected member properties and/or grades as the joint being designed. Tests shall be carried out in accordance with ISO 16670 and joint properties determined in accordance with ISO/TR 21141. Determination of characteristic values shall be made in accordance to ISO 12122 5 or ISO 12122 6 as appropriate.” [ISO 22156:2021 §10.2]

This paper demonstrates the determination of bamboo joint properties by complete joint testing. The moment resisting behaviour of a bolted fish mouth connection is selected to elaborate upon and demonstrate the entire process of complete joint testing on a simple connection type. The procedure described includes determination of experimentally measured and derived joint performance parameters and subsequent normalization of these. Statistical analysis of results and the determination of characteristic values necessary for design are described. Critically, the limitations of the complete joint testing protocol are described. A summary of the complete joint testing requirements is shown in Figure 1 on following page.

Although not the focus of the paper *per se*, the bolted fish mouth joint tested exhibited considerable variation of performance parameters resulting in relatively low characteristic design parameters of yield strength, ultimate strength and rotational stiffness.

Keywords: *bamboo, joint, structural testing, fish mouth joint, design parameters, design standard*

The novel low-rise bamboo culm structure building system composed of prefabricated frame units

Xin Zhuo, Si Chen, Baiyu Chen, Xiling Qiu*

*Zhejiang University, Hangzhou, China
zhuoxin@zju.edu.cn (*Corresponding Author)*

Abstract: Nails or ropes are used as connectors in conventional bamboo culm structures. These friction-based joints will become slack gradually as the moisture content of the bamboo or the temperature of the surrounding environment changes.

- 1) A novel bamboo culm structure system composed of polygonal frame units connected in parallel by bolts was proposed. All frame units have two-dimensional joint shapes. This feature allows the joint to have enough space to reinforce its mechanical properties.
- 2) The rectangular, trapezoidal, and triangular shape frame units were proposed based on bamboo properties and structural performances. It is conducive to manufacturing the frame units on the production line and easy to store in the factory.
- 3) Taking structural safety and living comfort into consideration, configurations for connecting the flexible layer of thermal insulation and waterproofing with the rigid layer of bamboo culm structure were proposed, and a set of construction technologies for the low-rise original

bamboo structure building were established.

4) The intelligent algorithm for configuring the structural modules was proposed after considering the courtyard's purpose and the reasonable performance of the low-rise original bamboo buildings. After programming, it is convenient to configure and optimize several modules as well as the spatial layout in the courtyard.

The results of the full-scale model experiment and virtual reality simulation demonstrated that the low-tech method of producing components and erecting structures is simple to spread, particularly in rural areas. The high-tech parametric design method allows architects to optimize courtyards more efficiently.

Keywords: *low-rise building, bamboo structure, frame unit, construction technology, parametric design*

3D characterization of vascular bundle in Moso bamboo node and its effect on mechanical properties

Qi Chen^{1}, Jinqiu Qi¹, Jiulong Xie¹, Benhua Fei²*

*¹ Sichuan Agricultural University, Chengdu, China
18010503597@163.com (*Corresponding Author)*

² International Centre for Bamboo and Rattan, Beijing, China

Abstract: Properties of the bamboo node obviously differed from those of the internodes due to structural differences. The three-dimensional (3D) structure of moso bamboo nodes, the most economical and ecological bamboo species in China, was still unknown. Thus, the 3D structural changes of the vascular bundle (VB) in the moso bamboo node were visualized and quantified. The results showed that the horizontal VB in bamboo node was classified into three types: branching, cross-linking, and thickening. The branching type was further divided into monopodial branching and dichotomous branching. All the vertical VBs shifted to the outer side after passing through the node (approximately 1 mm). The area increase rates of VB at the node in the outer, middle, and inner parts were 49%, 48%, and 113%, respectively. Besides, at the node, both the fiber bundle and the conducting tissue reached the maximum area. The 3D morphological changes helped explain the differences in mechanical properties between bamboo nodes and internodes. This study provided a theoretical foundation for further moso bamboo processing and utilization.

Keywords: *Moso bamboo, node, vascular bundle, three-dimensional structure, branching*

Research report on bamboo and plastic building materials and low-rise prefabricated buildings

Lu Chen Zheng

*Fujian Liuzheng New Material Technology Co., Ltd, Fujian, China
411359584@qq.com (Corresponding author)*

Abstract: Bamboo and plastic composite material has better properties than individual wood material but plastic products, and is an ideal substitute for wood. Its appearance can reduce the pollution of waste wood and plastic to the urban environment, and also adapt to the law of modern material composite development. With the development of modern industrial technology, parts for building houses can be made in batches in factories. As long as the prefabricated house components, transported to the site assembly assembled. This paper briefly introduces the composition, characteristics, processing technology and application of bamboo composite structure parts in China, and analyzes the development direction of bamboo composite prefabricated building, and fully affirms the necessity and feasibility of developing bamboo composite and prefabricated building.

Keywords: *green, environmental protection, cycle, fast*

Constructing strong, safe, lightweight and sustainable river and coastal boats using bamboo mat board laminates

Ravi Jyoti Dek

*Akvotransiro Tech Pvt Ltd, Guwahati, India
ravideka@gmail.com*

Abstract: To address the persistent problem faced by millions in developing countries, who risk their lives on unsafe, unstable, leaky wooden country boats due to a lack of alternatives, to the more recent challenge of disposing of hundreds of thousands of old, damaged and non-recyclable FRP boats in the western world; we developed a process for building strong, safe, sustainable and biodegradable Bamboo based Bio-composite Boats.

Constructed with composite sandwiches of compressed Bamboo Mat Boards laminated on both sides with marine-grade epoxy resin and fibreglass cloth, these boats are comparable in strength, impact resistance and water tightness to traditional moulded fibreglass boats. They are also much lighter, more efficient, more affordable and sustainable as they consist of 85% Bamboo, with about 10% polymers and only about 5% fibreglass. FRP boats usually have a 40/60 mix of fibreglass and thermoset resin- neither biodegradable nor easily and economically recyclable. So with Bamboo being the major construction raw material and low polymer content, our boats have the lowest carbon footprint of any modern composite boat construction method and are almost fully biodegradable at the end of their working lifespan of 10-15 years. Unlike FRP boats, they are constructed without moulds and are even simpler to build than traditional wooden ones. Thus, various designs and sizes of vessels for both rivers and coastal

areas can be built using this process without requiring a highly skilled labour force- from simple rowboats and fishing boats to multi-hull catamarans.

Keywords: *bamboo, boats, bio-composites, laminates, sustainability*

Small-diameter bamboo for low-cost housing in Myanmar

R. Ascoli

*Housing NOW, Yangon, Myanmar
raphael.ascoli@blue-temple.com (Corresponding Author)*

Abstract: In the midst of a nationwide civil war, Myanmar has seen a rapidly increasing number of internally displaced communities. Housing has become an urgent, and major need throughout the country. This research examines ways to implement a large-scale production of prefabricated low-cost bamboo houses.

By using an unconventional construction technique that is based on the bundling of small-diameter bamboo, an abundant and cheap resource in the local market, the cost of construction drastically drops. This system of interlocking structural frames allows for easy transportation and modularity in the design. This new construction methodology allows for a quick response to emergency housing crises and offers a new option to families in need of decent shelter without having to resort to shark loaners.

After three years of research, going from the computational design stage with topology optimization software, building six 1:1 scale prototypes to test out the design, improving the construction process incrementally, and structurally speaking testing the house in terms of resistance to dead-load, and wind-load, the initiative has already implemented its first pilot project which consisted of building free-of-charge houses in refugee camps near Bago, north of Yangon.

Keywords: *Bamboo, bundle, housing, Myanmar*

Bamboo-inspired cell-scale assembly for energy device applications

Q. Lin¹, R. Gao², D. Li³, Y. Lu¹, Y. Yu.¹, Y. Huang^{1}, W. Yu¹*

¹ *Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing, China
yxhuang@caf.ac.cn (*Corresponding Author)*

² *Northeast Forestry University, Harbin, China*

³ *Qindao University, Qindao, China*

Abstract: Rapid advances in flexible and wearable smart textiles demand low-cost, high-energy/power-density fiber-shaped supercapacitors (FSCs). The performance of FSCs is

determined by the fabrication and assembly of fiber-shaped electrodes (FSEs), where an active charge-storage material is always clad around flexible charge transmission current collectors. Inspired by the tissue structure of natural bamboo, wherein parenchyma cells (PCs) that store nutrients are clad around bamboo fibers (BFs), we propose a strategy for converting bamboo cells into FSEs using conductive BFs and activated PCs as current collectors and active materials, respectively. The assembled electrode has a high specific capacitance of 1454 mF cm⁻² at 0.64 mA cm⁻². A solid-state FSC with a pair of bamboo-structured electrodes exhibited a substantially high energy density. Its mechanical flexibility enabled the knitting of wearable wristbands to drive ultra-small voltmeter indicators. This lightweight, low cost, and high-energy-density bamboo-structured FSC could enable numerous smart textile applications.

Keywords: bamboo, bamboo fibers, bamboo parenchyma cells, fiber-shaped supercapacitor, energy device

Improved interfacial performance of bamboo fibers/polylactic acid composites enabled by a self-supplied bio-coupling agent strategy

Xiaoyang Fang^{1,2}, Yanchen Li^{1,2}, Junqi Zhao^{1,2}, Jianuo Xu^{1,2}, Chuanchuan Li^{1,2}, Jiaxun Liu^{1,2}, Yi Liu^{1,2,3*}, Hongwu Guo^{1,2,3*}

¹ Key Laboratory of Wood Material Science and Application (Beijing Forestry University), Ministry of Education, Beijing, China

² Beijing Key Laboratory of Wood Science and Engineering, Beijing Forestry University, Beijing, China

³ National Forestry and Grassland Engineering Technology Center for Wood Resources Recycling, Beijing Forestry University, Beijing, China
1730572316@qq.com

liuyichina@bjfu.edu.com; ghw5052@163.com (*Corresponding author)

Abstract: Natural fibers reinforced biopolymer composites (NFRBC) are attractive alternatives to petroleum-based plastics due to their renewability, carbon neutrality, and degradability. However, the incompatibility between the fibers and the polymer matrix has long been considered a challenging issue that prevents NFRBC from being widely used. The most common approach to overcome this problem is through surface modification of natural fibers, which always involve toxic or unsustainable reagents. Here, we focused on a cleaner and more sustainable way to address this issue. By using the deep eutectic solvent system, we successfully deposited a layer of lignin on the surface of the bamboo fibers to serve as a bio-coupling agent, self-supplied from the bamboo fibers rather than using exogenous lignin, petroleum-based coupling agents, or toxic reagents, which is more resource and energy efficient. The results indicated that the obtained bamboo fibers could simultaneously achieve interface compatibility enhancement and polylactic acid (PLA) matrix toughening. The PLA-based composites exhibited clearly better performance, including mechanical strength (the bending strength, tensile strength, impact strength, and elongation-at-break increased by 33.10%, 72.29%, 44.38%, and 40.80%, respectively), thermal stability (the T_{onset} increased from 290.6°C to 331.9°C), and water resistance (the water absorption decreased from 12% to

8%). Overall, with only renewable, eco-friendly, and non-toxic raw materials applied, this work suggests a new way toward developing more sustainable, stronger, and cleaner bio-composites.

Keywords: *bamboo fibers, polylactic acid, bio-composites, lignin, interface compatibility*

Sustainability and innovation of bamboo winding composite pipe products

Meiling Chen¹, Benhua Fei^{2,}, Chunping Dai^{3*}, Ling Ye⁴*

¹ *Jiangsu Co-Innovation Center of Efficient Processing and Utilization of Forest Resources, College of Materials Science and Engineering, Nanjing Forestry University, Nanjing, China*

² *Key Laboratory of Bamboo and Rattan Science and Technology of the State Forestry Administration, Department of Bio-materials, International Centre for Bamboo and Rattan, Beijing, China*

*feibenhua@icbr.ac.cn(*Corresponding Author)*

³ *Department of Wood Science, Faculty of Forestry, The University of British Columbia, Vancouver, Canada*

*chunping.dai@ubc.ca(*Corresponding Author)*

⁴ *Zhonglin Xinzhou Bamboo-based Composites Technology Co., Ltd., Hangzhou, China*

Abstract: Bamboo Winding Composite Pipe (BWCP) is a novel product that reintroduces and modernizes the use of bio-based pipes in below ground water reticulation infrastructure, and can replace PVC and concrete pipe in many low to medium pressure water service and sewerage applications. Pipes are built to accommodate service pressures of up to 1.6 MPa, with a long-term hydrostatic pressure projection of 50 years. Maximum burst pressures are up to 3.75 MPa. The new technology overcomes the structure and performance limitations of earlier wood veneer-based hollow tubes by encasing helically wound layers of thin but strong bamboo sliver curtains in a protective matrix of gauze wrap, thermosetting resin and powdered bio-filler. Bamboo has unique and very high tensile strength fiber and aligning this around the pipe circumference produces a high strength, ductile and pressure resistant pipe. This fabrication technology is extremely versatile, producing pipes ranging from 150 mm to 5000 mm in diameter with a wall thickness of 9 mm–38 mm for a wider range of applications including non-round shells for train cars and modular housing construction. An integrated supply chain model of satellite fabrication sites for curtain winding elements at the source and centralized manufacturing of pipes close to market locations can provide employment and income for remote villages and increase transportation efficiency. BWCP is energy efficient, requiring less than a quarter of the energy of steel pipes per meter. It presents a significant potential for carbon storage over time, holding an estimated 0.5 t of sequestered atmospheric CO₂ per t of pipe manufactured.

Keywords: *bamboo, manufacturing, composites pipe, infrastructure, sustainability*

Performance of laminated bamboo lumber coated with water-based polyurethane against accelerated UV and natural weathering

B.U. Kelkar^{}, S.R. Shukla*

*Institute of Wood Science and Technology, Bengaluru, India
b.kelkar1792@gmail.com (*Corresponding Author)*

Abstract: The Laminated Bamboo Lumber (LBL) is an engineered composite produced by bonding thin strips of bamboo under high pressure and heat. Being a lignocellulosic material, the LBL is susceptible to degradation through various abiotic factors such as moisture, UV-radiations, temperature and oxidation. The performance of LBL can be improved by using protective surface coating such as polyurethane. In this study, the LBL was prepared by using strips of *Bambusa bambos*, bonded with phenol formaldehyde adhesive in a hydraulic hot press. LBL samples were coated with water-based polyurethane (PUW) and exposed to accelerated UV and natural weathering (NW) conditions for 250 h and 90 days respectively. The resultant changes in surface colour, roughness, wettability, chemistry and microstructure were evaluated using characterization techniques such as colorimetry, surface profilometry, contact angle, FT-Infrared Spectroscopy and Scanning Electron Microscopy. The results revealed that uncoated LBL exhibited severe degradation showing photo-yellowing and darkening of the surface due to photo-degradation of lignin, increased roughness, wettability and surface cracking after exposure to weathering regimes. The PUW coated LBL showed significantly lower changes in colour, surface roughness and wettability parameters after exposure to UV and NW. The PUW coating provided substantial resistance to LBL against UV and NW conditions and can be used to protect the bamboo composites in long term outdoor applications.

Keywords: *bamboo lumber, polyurethane, weathering, photo-degradation*

Development of high capacity fibre reinforced bamboo composite structural members

Talakokula. V¹, Bhalla. S², Bhagat. D²

¹ *Mahindra Ecole Centrale School of Engineering, Mahindra Unviersity, Department of Civil Engineering, India*

² *IIT Delhi, India*

Abstract: The government of India has started “Pradhan Mantri Awas Yogna”, “Housing for all by 2022” etc to meet the demand of housing and permanent infrastructural need of the country which invariably cast an adverse impact globally as carbon-dioxide (CO₂) is one of the undesirable effluents of the steel and cement industry. For sustainable development it is imperative that the construction industry should look beyond concrete and steel, bamboo can be one of the best possible feasible technology, as it is said to be a “miracle plant” which can consume CO₂ from the atmosphere and can offer competitive performance w.r.t. Concrete and steel against strength to weight ratio. India has an abundance of bamboo with over 100 species

which are native to India, out of which 16 species are recommended for structural use by National Building Code (NBC). Hence Among the natural building materials, bamboo is unique for the extent of its negative carbon footprint, and it's extremely short maturity time, typically ranging from three to five years can be engineered to suit the present requirement for building a sustainable habitat. This paper specifically aims to develop an alternative material named high capacity bamboo composites (HCBC) using a series of bamboo culms reinforced with fibers using an adhesive. HCBC for multi-storey framed structures in earthquake zones can be a path breaking, transformative and disruptive technology. Using bamboo in its singular form possess a lot of challenges being a natural material with a lot of deficiencies and variability to overcome these drawbacks, series of culms are used to develop a composite section which can significantly enhance the capacity and reliability. This special fiber reinforced bamboo composite with epoxy provides the required ductility and durability to use as a primary structural material for building earthquake resistant structures. For this purpose multiple bamboo culms are integrated into a composite element using suitable adhesive/bonding agents with fibres as a binder reinforcement to develop beam and column composites (including joints) of high structural capacity with a moment sharing and transferring system as a portal frame which can also resist earthquake forces.

Long bamboo fibers in the innovative design

X. Meng

*School of Architecture and Urban Planning, Nanjing University, Nanjing, China
mxc@nju.edu.cn*

Abstract: As one of the swiftest growing woody plants, bamboo has a high capacity to capture and store carbon. It is considered a widely-used sustainable material in the future due to its strength-to-weight ratio, which comes from its natural fibers. Hence, bamboo is an ideal material to replace plastics. However, the formability of bamboo-based materials is poor compared to plastics, which makes processing them into versatile shapes difficult. Long bamboo fibers would be one of the key parts.

This study aims to reveal the essential role of long bamboo fibers in innovative bamboo applications and discuss challenges that could be solved using new techniques. First, the properties of long bamboo fibers are discussed. Then, cases are presented, discussed, and compared to plastic products. The comparison indicates that design strategies to organize long bamboo fibers both shapely and structurally hold great potential to improve the formability of bamboo-based material. Moreover, the manipulation of bamboo fibers highlights its unique property, which can get rid of the stereotype that bamboo is a poor man's wood. Integrating the moldable and mechanical properties of long bamboo fibers not only achieves a more attractive appearance but enhances durability and stiffness, which is still challenging. In the end, new technologies, including simulations, algorithms, and digital manufacturing, are discussed for their potential involvement in the integrated design of long bamboo fibers.

Keywords: *long bamboo fiber, design, formability, mechanics*

Serviceability of cross-laminated timber (CLT) floor considering the environments

H. Huang^{1*}, J. Zhang²

¹ Newcastle University, Newcastle, UK

haoyu.huang@newcastle.ac.uk (*Corresponding Author)

² Beijing University of Technology, Beijing, China

Abstract: Cross-laminated timber (CLT) is commonly used in the floor system. CLT floors have the characteristics of lightweight and flexibility compared with traditional reinforced concrete floors, which makes CLT floors more prone to annoying vibrations. The environment is one of the factors that may influence occupants' perception of the floor vibration and the assessment of floor serviceability. In this study, laboratory tests were conducted on a 3-ply CLT floor. Occupants' assessment of the floor serviceability under human-induced vibration was investigated. Virtual reality (VR) technique was used as a research method, simulating two common environments in life – bedroom and gym.

First, the correlation between occupants' annoyance rating and serviceability indicators (response factor and vibration dose value (VDV)) was compared with existing standards. The current limit values for response factor in ISO 10137 are conservative for timber floors in both bedroom and gym environments, while VDV criteria in BS 6472 can generally reflect the vibration acceptability of timber floor vibration in both environments. It is recommended that the limit values for response factors be increased approximately and more detailed classification of the environment be considered for VDV method.

Then, the effect of the environment and the acceleration response on floor serviceability assessment was investigated through statistical methods, respectively. The results showed that occupants had lower vibration tolerance in the bedroom than in the gym. The annoyance rating of floor vibration increases as the response acceleration gets larger, but in a weak manner.

Keywords: timber floors, cross-laminated timber panel, vibration serviceability, indoor environment

Growth room for China bamboo trade in the international market of the BRI countries

A. Danilova, X. Liu*

Tsinghua University, Beijing, China

xuehua-hjx@mail.tsinghua.edu.cn (*Corresponding Author)

Abstract: Bamboo is a unique fast-growing plant species which provides wide range of ecosystem services and have numerous applications around the world. Being the biggest exporter and producer of bamboo products around the globe, China has a great potential to further increase its export market of non-wood commodities through the continuous

proliferation of Confucius Institutes and the BRI organization.

This study aims to analyze bamboo export trade flows from China to its trade partners, to find the most influential factor(s) of the bamboo trade and investigate the impact of Confucius Institutes and membership in BRI as potential drivers. Based on these estimations, the attempt was made to predict the future trade flows of bamboo commodities and to see if there is a room for growth on the BRI countries market in the next ten years. Research methodology was based on literature review and application of powerful analytical tool of market export flows, the gravity model. The results have shown that having common borders with China and hosting Confucius Institute had the strongest positive impact on Chinese bamboo products, whereas distance still hinders the bilateral trade. BRI factor has a contradictory effect on bamboo export, showing negative result while being compared to major trade partners of China, however, witnessing the strong positive trend in latest years and impressive trade potential in next ten years.

It is recommended to the decision-makers to pay closer attention to countries of the BRI agreement as they provide a large room for growth in bamboo export niche.

Keywords: bamboo, sustainable development, international export trade flows, gravity model, Belt and Road Initiative

Facile preparation of chitosan-based composite film with good mechanical strength and flame retardancy

Jirui Chen ^{1,2}, Wentao Huang ¹, Yifan Chen ¹, Zenan Zhou ¹, Huan Liu ¹, Wenbiao Zhang ^{1,*},
Jingda Huang ^{1,*}

¹ College of Chemistry and Materials Engineering, Zhejiang A&F University, Hangzhou, China

² SuiChang Bamboo Charcoal Museum, Lishui, China

* Correspondence: zwb@zafu.edu.cn (W.Z.); hjd1015@163.com (J.H.)

Abstract: To improve on the poor strength and flame retardancy of a chitosan (CS)-based functional film, cellulose nanofiber (CNF) was taken as the reinforced material and both ammonium polyphosphate (APP) and branched polyethyleneimine (BPEI) as the flame-retardant additives in the CS matrix to prepare the CS/CNF/APP/BPEI composite film by simple drying. The resulting composite film showed good mechanical strength, with a tensile strength reaching 71.84 Mpa due to the high flexibility of CNF and the combination of CS, CNF and BPEI through strong hydrogen bonding interactions. The flame retardant-performance of the composite film greatly enhanced the limit oxygen index (LOI), up to 32.7% from 27.6% for the pure film, and the PHRR intensity decreased to 28.87 W/g from 39.38% in the micro-scale combustion calorimetry (MCC) test due to the ability of BPEI to stimulate the decomposition of APP, releasing non-flammable gases such as CO₂, N₂, NH₃, etc., and forming a protective phosphating layer to block the entry of O₂. Based on the good flame retardancy, mechanical strength and transparency, the CS/CNF/APP/BPEI composite film has a great potential for future applications.

Keywords: *chitosan, cellulose nanofiber, flame retardant, film, mechanical strength*

The bamboo gate of Zhangcun preliminary school

Gao Wei

*ADR Studio, Hangzhou, China
46128013@qq.com (corresponding author)*

Abstract: The design and construction process of Zhangcun Preliminary School's new gate is a collaboration of students, faculties, NGOs and designers. The function, form and material of this project are inspired and revealed by the site and students' proposals. With the help of students' insight, we developed a new form of bamboo structure to represent the tea leaves. The new bamboo-structure gate presents a bold gesture towards the public, by re-defining the gate as a place of communication and connection instead of separation. The use of bamboo is also a dream-come-true process for the students and faculties, showing their pride and creativeness.

Keywords: *gate, bamboo-structure, collaborative design, Zhangcun*

Energy-based time equivalent method for evaluating the fire resistance of timber components exposed to realistic design fire curves

Y.W. Zhang

*School of Civil Engineering, Southeast University, Nanjing, China
zhangyongwang@seu.edu.cn (Y.W. Zhang)*

Abstract: The core of the performance-based fire safety design philosophy is to allow fire safe design of building structures using realistic design fire models. However, the current code provides only one design method for the fire resistance of timber components under standard fires. Based on this, this paper proposes an energy-based time equivalent method to evaluate the fire resistance of timber components under realistic design fires. Design fire and standard fire tests are carried out with 60 glulam specimens each of glued laminated timber (GLT) and cross-laminated timber (CLT) to verify the effectiveness of the energy-based time equivalent method. The results show that for the glulam specimens (GLT or CLT) exposed to the design fire and the standard fire respectively, the charring depth and the temperature distribution of the pyrolysis layer of the glulam specimens have good equivalence if the transferred heat is equal. Except for a few fire scenes, the relative error values of the charring depth of the glulam specimens are all within 10%. Except for the iBMB parameter fire, the temperature distribution of the pyrolysis layer of the glulam specimens is approximately the same. The above conclusions fully confirm that the energy-based time equivalent method can be effectively used to evaluate the fire resistance of timber components under realistic design fires.

Keywords: performance-based design, realistic fire design, timber components, energy-based time equivalent method, equivalent time

A decade of technological support for bamboo design

M. Tedjosaputro^{1*}, B. Kevin²

¹ Xi'an Jiaotong- Liverpool University, Suzhou, China
mia.tedjosaputro@xjtlu.edu.cn (*Corresponding Author)

² Aksen PM, Surabaya, Indonesia

Abstract: With the advancement of digital design thinking and tools, it facilitates the development of bamboo design and bamboo architecture; in particular, the way digital design allows manipulation of form, technique and fabrication which was not possible to achieve without digital tool's support before. This paper aims to provide a snapshot of technological support in bamboo design during the last decade. A comparative study is conducted through thirteen case studies using bamboo as the main material ranging from the use of algorithmic design, additive manufacturing, holographic construction, robotic fabrication and combinations of these. The research question which the authors try to address is “*What are design affordances offered by technology in shaping digital bamboo design?*” In this paper, *design affordances* refer to what the digital design tools and environment offer (design potentials) which are not commonly present without the use of the particular digital tools. Discussion is expanded through three central themes of classical tectonics: technique, culture, and material. The expected outcome of this paper is to provide suggestions for digital bamboo design direction, and to provide a forecast in the scope of bamboo design and architecture. It is also expected that directions for computational bamboo design are laid out, along with pedagogical support to introduce bamboo at an undergraduate level of architecture study (in places where bamboo is in abundance).

Keywords: bamboo architecture, computational bamboo design, bamboo for architecture pedagogy, digital bamboo design

Mode I translaminar fracture of cross-laminated bamboo and layup effects

Yao Wu¹, Shengjie Liu¹, Zhi Li^{2*}, Zhichao Wan¹

¹ College of Civil Engineering, Nanjing Tech University, Nanjing, China

² College of Civil Engineering and Architecture, Zhejiang University,
Hangzhou, China

Abstract: Timber and bamboo constructions have attracted more and more attention over recent years as they have a potential negative carbon emission from material to building. Another reason for the development of timber constructions is the commercial launch of timber

products. Cross-laminated timber (CLT) originated in the 1990s and has been used in multi-story buildings because of its advantages in bidirectional loading and seismic energy dissipation. Cross-laminated bamboo (CLB) is a relatively new product that can be used as an option for substituting CLT. The current work is the fracture studies of CLB, as fracture mechanics has gradually become an essential structural analysis method, especially for structures with prefabricated openings. For analysis of CLB structures with fracture mechanics, the effective modulus, R-curve, steady fracture toughness and cohesive traction-separation law are obtained. Additionally, the deformation capacity in the elastic stage and energy dissipation capacity of the CLB are studied. Furthermore, the layup effect on fracture parameters is investigated with four kinds of CLB fracture specimens. The correlation between the fracture parameters and the number of layers is deduced for CLB.

Keywords: *cross-laminated, R-curve, fracture toughness, bamboo, layup effect*

Numerical simulation research on long-term and short-term flexural performance of steel-timber composite beams

L. Xinhao, S. Zhongxu, P. Kang*

*Southeast University, Nanjing, China
1296986453@qq.com (*Corresponding Author)*

Abstract: This paper is based on simplified Hashin criterion, with the help of finite element software subroutines to complete secondary development of timber elastic-plastic constitutive model. On this basis, steel timber composite beam models with full shear connection and partial shear connection are established. The failure mechanism and the influence of shear connection degree on short-term flexural performance of composite beam is investigated under four-point bending test. The creep limit is determined by static loading. Then the user material subroutine considering timber creep is compiled to study the effect of shear connection degree on the creep of composite beams under long-term load, analyze the stress redistribution phenomenon caused by creep and give the long-term creep coefficient of composite beams. The results show that under the short-term loading situation, the lower timber beam flange of the composite beam reaches the tensile strength limit and leads to the ductile bending damage of the composite beam, the degree of shear connection has a great influence on the ultimate bearing capacity and a small influence on the initial secant stiffness. Under the long-term loading situation, a significant stress redistribution phenomenon occurs in the composite beam, the creep coefficient of composite beams subjected to 1-year long-term loading are between 0.13 and 0.18. The creep coefficient of composite beam increases with the increase of the degree of shear connection.

Keywords: *steel-timber composite beam, numerical simulation, constitutive model, flexural behaviour, creep*

Study on fire resistance of modified wood cladding on glulam columns

Xuesong Song, Kong Yue, Feng Wang

*Nanjing Tech University, Nanjing, China
2271133126@qq.com*

Abstract: Previous researches have shown that wood combustion performance may be considerably enhanced by combining resin impregnation with compression. In this investigation, fast-growing Chinese fir lumbers were impregnated with a 30% concentration of borate-containing phenol-formaldehyde resin with, followed by compression with a compression ratio of 30%, and used as an exposed side lamina of glulam columns. Under one-side fire exposure, the fire performance of full-scaled glulam columns was evaluated in this study. The results demonstrated that the combining resin impregnation and compression to treat the laminate significantly extended ignition time by 55s - 195s of the glulam column, and improved the fire resistance of the glulam column. The charring rate of glulam column with single modified lamina decreased from 0.733 to 0.552 mm·min⁻¹ after 60 min fire exposure. At a fire duration of 120 min, charring rates of glulam columns were reduced from 0.503 to 0.458 and 0.351 mm·min⁻¹, respectively, when single or double modified laminae were used. The residual bearing capacity of these columns with single modified laminate was enhanced by 30.1% at 60 min duration compared to the control, and by 69.3% at 120 min for those with double laminae. The residual cross section of glulam columns decreased with the fire duration, and the failure modes changed from strength to instability failure in compression test.

Keywords: *fast growing Chinese fir, glulam column, wood modification, charring rate, residual capacity*

Experimental investigation into the fire-resistance performance of wood-framed walls sheathed with gypsum-wheat-straw composite

Tianyi Wu, Kong Yue, Bing Liang

*Nanjing Tech University, Nanjing, China
1463623768@qq.com*

Abstract: Gypsum board (GB) is used as a fire-resistant component of light wood frame (LWF) walls for its excellent fire resistance; nonetheless, cracking and separation cause LWF failure owing to water release at high temperatures. In this study, an innovative gypsum-wheat-straw composite (IGW) was produced, and fourteen mesoscale LWF walls were tested to determine the effects of IGW on fire resistance using the ISO 834 standard. Six LWF walls were burned until failure for determination of fire endurance. Eight LWF walls were heated for 30, and 60 min during a standard fire and followed by compression testing. The results indicated that the temperature in IGW-sheathed walls grew more slowly than in GB-sheathed walls during fire testing. The IGW-wall had a fire endurance of 127 min, which was 44.3% higher than GB-wall. In the double sheathing structure, the fire resistance of the IGW-wall is

extended by 51 min, and the temperature rise rate of the wall studs is reduced by 2 to 3 times. The residual morphology of IGW was shown to be intact after the same duration fire tests, compared to GB. The residual bearing capacity of IGW-wall reinforced by the fire-exposed panel joints is 21.3% higher than that of GB-wall burned for 30 min during standard fire. Under a 60 min duration exposure, the residual bearing capacity retention rate of the IGW-wall was 65.4%, while the bearing capacity of the GB wall was lost. IGW had more excellent fire resistance and can beneficially replace GB in LWF wall.

Keywords: *gypsum-wheat-straw composite, light frame wall, fire resistance, residual bearing capacity*

Experimental study on axial compression of aluminum timber composite columns

*Y. L. Fan *, P. Peng, Y. L. Hu*

*Central South University of Forestry and Technology, Changsha, China
fanyunlei@163.com (*Corresponding Author)*

Abstract: In order to study the axial compression performance of rectangular hollow aluminum alloy timber composite columns (ATC), nine ATC columns and nine rectangular hollow aluminum alloy columns (RHA) were designed for comparative test. The load-strain relationship and load-displacement relationship of columns with different slenderness ratios and thickness of aluminum tube were explored. The failure mechanism and failure form were analyzed, and the ultimate bearing capacity of ATC columns was preliminarily deduced. The results show that when the height of RHA and ATC columns is the same, the bearing capacity increases in varying degrees with the increase of the thickness of aluminum tube, and the stiffness and overall stability of the columns are also improved. When the thickness of aluminum tubes of RHA and ATC columns is the same, the greater the slenderness ratio of the columns, the weaker the stability. The bending stiffness of RHA columns in the long side of the section is smaller than that in the short side of the section. Due to the restraint of aluminum tube, the timber is in three-dimensional compression state, which makes the initial stiffness of ATC columns increase, and the ultimate bearing capacity of ATC columns increases by 58.4%-838.3% compared with RHA columns. The calculation method based on superposition theory is in good agreement with the test results.

Keywords: *rectangular hollow aluminum alloy timber composite column (ATC), rectangular hollow aluminum alloy column(RHA), slenderness ratio, axial compression, ultimate bearing capacity*

Bending stress prediction of *Oxytenanthera abyssinica* bamboo based on geometric section

M. Tadesse^{1*}, *A. Denamo*², *J. Goedert*³

¹ *Bahir Dar University, Faculty of Civil and Water Resource Engineering, Bahir Dar, Ethiopia*

*tadessemm@gmail.com (*Corresponding Author)*

² *Ababa University, Ethiopian Institute of Architecture Building Construction and City Development (EIABC), Addis Ababa, Ethiopia*

³ *University of Nebraska Lincoln, the Durham School of Construction Engineering and Architecture, Omaha, USA*

Abstract: Unlike steel and concrete, there is no definitive data for obtaining modulus values of bamboo and strength results that differs from species to species. This study investigates the geometrical characteristics of *Oxytenanthera Abyssinica* bamboo at the age of 2, 3 and 4 years for prediction of flexural capacity based on the natural sturdiness of the culm. Solid culm cross-sections of *Oxytenanthera Abyssinica* bamboo resemble to wood, but are anatomically different in their mode of growth and tissue organization. The culm has a solid cross section for a length of 2.5-3.2m with a diameter range of 3-9 cm bottom diameter when fully matured. Three critical geometrical section along full culm of the bamboo were observed at longitudinal section. The solid, semi-solid and hollow sections are systematical classified and related with the bottom diameter and average internode lengths. Flexural test of full culm under 3-point static loading was conducted. The load arrangement on the full culm specimen was according to ISO 22157. A statistical and experimental results showed that the ratio of bottom diameter with the average internode length (D) has good indicators for determining the length of solid section and the concomitant flexural strength of the species at a moisture content of 11-13%. Hence, bending strength values of the solid section is predicted linearly with 5.8D, 6.4D, and 7.2D for age of 2, 3 and 4 respectively. Despite the lower diameter nature of this bamboo species, it has a solid section that can be linearly related to predict flexural strength.

Keywords: *solid culm, geometric section, bending strength*

Bamboo as a sustainable and economy construction material: a comparison between the R.C.C structure and bamboo structure

S. Biswas

*Dept. of Global Smart City, Sungkyunkwan University, Suwon, South Korea.
sumanbiswas@g.skku.edu*

Abstract: Now-a-days, Bamboo structure is not a fancy thing, but also an easy, available and sustainable material in the construction industry. Bamboo is a fast-growing plant with a long-life span in terms of its usage. When the whole world is aware about using green and sustainable materials, bamboo is the best solution for building human habitat. This study deals with the

economical and engineering sides of Bamboo construction. Here a comparison analysis will be conducted between the common worldwide practised R.C.C structure and neglected Bamboo structure. Two successful projects in Bangladesh designed by two young Bangladeshi architects are critically sectioned and analysed to get the feasible answer about the long-term prospect of Bamboo structure. The analytical study consequently recommended that bamboo is not only a green and sustainable material in the recent era, but also economically cheaper and easily buildable with an expected period of usage than any other materials. However, the common challenges which are related with the use of bamboo as a construction friendly material such as attack by insects and fungi can be eliminated with the use of chemical and non-chemical preservative treatments that improves the durability of Bamboo structure. Finally, from the architectural point of view how we can bridge the use of bamboo for our inclusive infrastructure in the developing countries in respect of its aesthetic, engineering, economic and social aspect.

Keywords: *bamboo, sustainable architecture, green construction, inclusive infrastructure*

Design and construction of lightweight bamboo-wood structure based on building information model, the case study of a residential house in Zhangbei, China

R. Wang¹, Z. Li^{2}, G. Wang³, Y. Xiao¹*

*¹ Zhejiang University - University of Illinois at Urbana-Champaign Institute,
Haining, China*

*² Zhejiang University, Hangzhou, China
Li_zhi@zju.edu.cn (*Corresponding Author)*

³ University of Hainan, Haikou, China

Abstract: A residential two-story hybrid bamboo-wood house was designed and built in Zhangbei, China, based on building information model (BIM) platform software. The structure form of the house was a lightweight bamboo-wood structure that comprised the primary structural framing members and sheathings, including shear walls, floor systems, and trusses. This type of structure has good lateral-resistant performance. The shear walls perpendicular to the lateral force can transfer the load to the horizontal diaphragms (floor or roof). The horizontal diaphragms distribute it to the shear walls parallel to the lateral force; and, finally, transfer the force to the foundation. The structural elements were connected by prefabricated metal connection. A BIM model of the house was established to simulate the construction process. Revit families of lightweight shear walls, gird, and roof trusses were created, and according to the 3D files, the structural elements were prefabricated in the factory. The prefabricated hybrid structure obtained a relatively right balance between structural requirements and economic benefits, thanks to easy manufacture, transportation, prefabrication, and installation.

Keywords: *bamboo, residential house, BIM, prefabricated, lightweight frame structure*

Effects of hydro-thermal treatment on the bending properties of Moso bamboo

Sijie Niu¹, Meiling Chen², Baixiang Cui¹, Chuangui Wang^{1}, Shuangyan Zhang^{1*}*

¹ Anhui Agricultural University, Hefei, Anhui, China

*² Nanjing Forestry University, Nanjing, Jiangsu, China
sijieniu@icloud.com*

Abstract: This study focused on investigating the effects of different chemicals, bath temperature and bath time on physical and mechanical properties of Moso Bamboo during hydro-thermal treatment. Treat the bamboo with acid or alkaline water bath, meanwhile, the bath temperature and the bath time were controlled to explore the change of bending properties of bamboo under different treatment conditions. The results showed that the bending properties of Moso Bamboo were negatively correlated with bath temperature, bath time and treatment solution concentration. The effect of acid solution on the bending property of bamboo is slightly higher than that of alkaline solution. Among them, the influence of bath time on bending properties of Moso bamboo was the most significant. Compared with untreated bamboo, the elastic modulus and static bending strength of bamboo decreased 16.4%~28.8% and 15.3%~35.6% respectively. At the same time, the curvature radius of thin bamboo unit decreased obviously.

Keywords: *Moso bamboo, softening process, acid or alkali bath treatment, bending strength, radius of curvature*

The sound insulation performance of bamboo nail reinforced cross-laminated timber

Yue Wu, Yixin Zhu^{}, Zilan Huang*

*Nanjing Forestry University, Nanjing, China
zhuyixin@njfu.edu.cn (*Corresponding Author)*

Abstract: In the field of biomass composite building materials, a bamboo nail reinforced cross-laminated timber (BN-CLT) has been developed in order to take advantage of the low-carbon benefits of bamboo instead of wood and the excellent mechanical properties of bamboo scrimber, as well as to improve the rolling shear properties of cross-laminated timber (CLT) and its sound insulation properties when used as a floor slab. The new material retains the form of CLT, the laminate is made of domestic fir wood as the substrate, with periodically arranged pre-drilled holes in which square bamboo scrimber nails are nailed as scattering bodies, the length of the nails being the same as the thickness of the CLT.

The sound insulation performance of bamboo nail reinforced cross-laminated timber was investigated in the frequency range of 50-2000Hz using simulation calculations and the impedance tube method. The results showed that the overall sound insulation performance of bamboo nail reinforced cross-laminated timber was higher than that of domestic fir CLT. In

the frequency range of 200-600Hz, there were significant peaks in the sound insulation curves of bamboo nail reinforced cross-laminated timber, indicating that the periodically arranged bamboo nails suppressed the propagation of sound waves at low and medium frequencies. The diameter and spacing of the pre-drilled holes in bamboo nail reinforced cross-laminated timber affected the distribution and peak of the sound insulation curve, resulting in different sound insulation effects.

Keywords: *bamboo nail, cross-laminated timber, sound insulation properties*

Feasibility study of bamboo-wood composite cross-laminated timber made from Dragon bamboo and *Eucalyptus urophylla*

Su Xinlong, Han Chenyu, Wan Hui

*College of Materials Science and Engineering, Southwest Forestry University, Kunming
Yunnan, China
wanandwan@yahoo.com*

Abstract: In order to further promote the green and sustainable development strategy of forest products, explore the possibility of replacing wood with bamboo. This paper uses Dragon Bamboo and Eucalyptus wood to make Cross laminated timber (CLT) model to explore the effects of bamboo green on the performance of model, which included the bending strength and dimensional stability and strength-to-weight ratio. The comparison with the CLT model of pure Eucalyptus wood shows that the Bamboo-Eucalyptus wood CLT model had higher flexural strength and better dimensional stability, when the surface material of the bamboo-wood CLT model was bamboo and the core material was Eucalyptus wood and when the model was bonded with hybrid phenol formaldehyde-isocyanate resin. The performance of the Bamboo-Eucalyptus wood CLT model met the requirement of CLT standard LY/T3039-2018. It has been confirmed that when the design of gluing the diameter section of bamboo strips and Eucalyptus chord section and using bamboo strips as the surface layer, the tensile failure at the bottom of the bamboo wood CLT model will be avoided, and the dimensional change of the bamboo wood CLT model is much lower than that of the wood CLT model and the simple tail giant eucalyptus and dragon bamboo, which improves the dimensional stability of the bamboo wood CLT model. This provides a reliable basis for manufacturing bamboo wood orthogonal plywood with high dimensional stability and strength, and proves the feasibility of making CLT with dragon bamboo instead of some wood.

Keywords: *bamboo utilization, bamboo and wood composite, clt, dimensional stability, bamboo bonding interface*

Textile materials and textile structural composites based on bamboo fibril

W. Chunhong^{1*}, L. Chao¹, Z. Yi², L. Suwen¹

¹ Tiangong University, Tianjin, China

wangchunhong@tiangong.edu.cn (*Corresponding Author)

² Fujian bamboo fiber material technology Co., Ltd, Fujian, China

Abstract: Bamboo fibril is fiber bundle extracted from bamboo by physical and chemical methods. It retains the structural and functional characteristics of the original bamboo and shows broad application prospects in traditional textile and textile structural composites industry. In this paper, the utilization of bamboo fibril is described from three aspects: bamboo fibril extraction, textile material processing and textile composite reinforced with bamboo fibril. Significant differences were identified between external and internal bamboo fibril in the aspect of morphology and mechanical properties. Internal bamboo fibril/cotton blended yarn and fabric with blending ratio of 50:50 was prepared by using compact Siro-spun and woven technology. The strength of the blended yarn was 9.2cn/tex with elongation at break of 4.7%. Favorable UV protection and antibacterial function was exhibit in blended fabric with ultra violet protection factor greater than 50 and transmittance of UVA less than 5%. The fabric style analysis indicated the blended fabric was suit for clothing fabrics, bedding, etc. The flexural strength and modulus of the thermoplastic composites reinforced with bamboo fibril nonwoven felt were 74.0MPa and 6.1GPa, and the tensile strength and modulus were 57.0MPa and 6.2GPa, respectively, which met the mechanical demands of automotive interior materials. The unidirectional external bamboo fibril reinforced unsaturated polyester composite had a tensile strength of 434.6MPa, tensile modulus of 15.8GPa, flexural strength of 370.5MPa and flexural modulus of 25.0GPa. The flame retardant grade reached UL-94 V-0 with damage length of 31.0mm and no melting drop during vertical combustion. It has application prospects in the fields of automobile, aviation, rail transit, marine, wind power blades, engineering pipes and building materials.

Keywords: bamboo fibril, textile materials, textile structural composites

Bamboo bridge in Tao Sense art park

Zhang Jian

Design Center of Haoyuan Group, Guangzhou, China

Kenny@Mcwartz.cn

Abstract: From the CBD of Guangzhou, it takes a 50-minute drive to Hongshi Village, Taiping County of Conghua District. At the end of the village road, is an isolated landscape: Shaxi Reservoir. Surrounded by a thick forest of more than 10,000 mu is a clear mountain lake. In between lies the art park of Tao Sense.

The highway bridge of Tao Sense crosses the wetland. Two huge concrete piers stand on the canyon wetland, which looks rough as if not belong to the landscape.

We reconstructed a bamboo bridge to make it look more harmonious with the wetland landscape.

The design of the structure is inspired by the meandering streams and the flowers wetland. The two elegant curves changed the rigid skyline of the bridge and created a new landscape for the wetland.

The bridge is almost 100 meters in length and 10 meters in width. The need to accommodate large trucks, fire engines and other high vehicles has posed a challenge for the design due to the restricted clear height of the structures. The spatial positioning of the curve has to balance the transportation demand and the appearance. The visual effect is checked from multiple viewpoints to finally determine the form of the bridge.

Keywords: *bamboo bridge, aesthetics, curve*

Influence of bamboo fibres on the mechanical behavior of high performance lightweight aggregate concrete

Qingfang Lv¹, Ran Zhu², Jing Shi¹

*¹Southeast University, Nanjing, China
101011003@seu.edu.cn*

²Shanghai Construction Group, Shanghai, China

Abstract: This experimental research aims to investigate the utilization of bamboo fibres in high performance lightweight aggregate concrete (HPLAC). The mechanical strength of HPLAC mixtures containing natural bamboo fibres and modified bamboo fibres with different lengths (7.5, 15, 22.5, and 30mm) and volume contents (0.1%, 0.3% and 0.5%) were tested. The results indicated that the cubic compressive strength of fibre reinforced concrete decreased with volume content of natural bamboo fibres increasing. Adding 0.1% volume content and 15mm modified bamboo fibres highly increased the splitting tensile strength of HPLAC. Compared with plain HPLAC specimens, the content of 0.1% natural bamboo fibres with a length of 15mm significantly increased toughness and energy absorption rate of HPLAC. Moreover, in the SEM images, the pull-out of the fibre from the matrix resulted in damage to the fibre peeling off the surface leading to a good mechanical anchoring mechanism.

Keywords: *bamboo fibre, high performance lightweight aggregate concrete, mechanical performance*

Bamboo fiber-reinforced epoxy resin composites prepared by vacuum-assisted resin transfer molding process: effect of fiber morphology

Jiangjing Shi¹, Hong Chen¹, Wenfu Zhang², Changlei Xia^{1}*

*¹Nanjing Forestry University, Nanjing, China
changlei.xia@njfu.edu.cn (*Corresponding Author)
²Zhejiang Academy of Forestry, Hangzhou, China*

Abstract: This study aimed to explore the effect of different morphologies of bamboo fibers (BFs) on epoxy resin (EP) impregnation in vacuum-assisted resin transfer molding (VARTM) process and the properties of BF/EP composites. In this paper, three types of BFs with different morphologies (BF-2, BF-3 and BF-4) were obtained by mechanical rolling with 2, 3 and 4 times, respectively. Bamboo fiber preforms (BFPs) obtained by solution suspension method were used as reinforcement, and epoxy/anhydride system was employed as matrix; on this basis, BF-2/EP, BF-3/EP and BF-4/EP composites were prepared by VARTM. The properties of BFs, BFPs and BF/EP composites were characterized with ESEM, ultra-depth-of-field microscope, mechanical testing machine, TG, DMA and micro-CT. The results showed that the fluffy degree of BFPs decreased and the difficulty of resin injection increased when the fiber length decreased and the fiber separation increased. The fiber accumulation occurred during resin injection of BFP-4, and BF-3/EP composites had the lowest water absorption. The mechanical properties of the composites prepared by BF-3 with moderate length and separation were the best, and the flexural strength, flexural modulus, shear strength and impact toughness were 97.90 MPa, 7.2 GPa, 17.01 MPa and 8.11 kJ/m², respectively. The thermal stability of the EP was lessened with the BF incorporation. The high BF content significantly improved the rigidity of EP, and the BF/EP composites presented more excellent dynamic thermo-mechanical properties when prepared with BF-3. The interface bonding between BF-3 and resin was the best, and the proportion of pores volume was only 0.04%.

Keywords: *bamboo fiber, solution suspension method, vacuum-assisted resin transfer molding, fiber morphology, bamboo fiber composites*

Analysis optimization of bamboo pole trusses based on data from digitized bamboo culms.

Rodolfo Lorenzo, Barath Ragesh Puvanendran Maheswari

University College London, London, United Kingdom

Abstract: Bamboo is an ideal construction material that could help reduce carbon footprint in the construction industry. Although bamboo poles used in construction act as a carbon sink in their initial growth phase, it contributes to carbon dioxide emissions during treatment, transport, construction, and repairs. Apart from carbon emission, the codes for the structural design of bamboo underutilize the material on account of a large factor of safety. This is primarily due to the fact that the data from testing of the material show considerable deviation

in its mechanical and geometric properties, due to its organic nature. Emissions associated can be reduced and utilization can be increased by employing a data-driven digital design framework. This includes 3D scanning of bamboo poles and automated testing and using the data throughout its lifecycle along with BIM applications.

This paper deals with the analysis of a bamboo pole structure based on the digital design framework and compares its results against traditional analysis models of bamboo pole structures. In addition to the comparison, it shows methods by which deflections, stresses, and stiffness variation of the structure could be reduced. This is made possible by having a database from automated analysis of individual bamboo pole members from the digitized bamboo culm. The knowledge of bamboo culms and parts of poles to be used in structures identified by the methodology can improve the efficiency of the structure and its performance by improving the utilization of members in the structure.

Keywords: *bamboo structures, computer-aided design, computational modelling, structural optimization*

Transparent bamboo as novel green energy storage composites for thermal energy storage applications

Qiuyi Wang^{1,2}, Zhuchao Xu^{1,2}, Meiling Chen^{1,3}, Yanjun Li^{1,2*}*

¹ *College of Materials Science and Engineering, Nanjing Forestry University, Nanjing, China.*

*wang813@njfu.edu.cn (*Corresponding Author)*

² *National Engineering and Grassland Bureau Bamboo Engineering Technology Research Center, Nanjing, China.*

³ *Forestry Administration, Department of Bio-materials, International Centre for Bamboo and Rattan, Beijing, China.*

Abstract: With the rapid growth of building energy consumption and the increasingly serious environmental problems, in order to develop renewable energy and improve energy efficiency, new transparent biomass materials with heat storage functions have attracted wide attention as new building materials. Transparent bamboo has extraordinary thermal insulation and optical properties, which makes it a potential biomass building material. In this study, epoxy resin compound with phase change materials polyethylene glycol (PEG) were impregnated into the delignified bamboo (DB) to prepare a novel transparent energy storage bamboo (TESB) with high strength and low thermal conductivity. The results show that the addition of PEG improves the thermal stability and energy storage efficiency of TESB, and has slight influence on the light transmittance. With the increase of PEG content, the phase transition enthalpy of TESB increases gradually. When the PEG content is 80%, the synthesized TESB has the best thermal properties. The melting enthalpy and crystallization enthalpy are 134.1 J/g and 122.9 J/g respectively, the maximum transmittance is 88.2%, and the tensile strength is 122.72 MPa. Our work provides a potentially industrial way for green energy storage composites fabrication, and the obtained TESB with excellent overall performance are promising for building energy conservation and indoor thermal comfort improvement.

Keywords: *transparent energy storage bamboo, optical properties, thermal properties, high strength, thermal energy storage.*

Effects of irradiation treatment on physical and mechanical properties and mildew resistance of reconstituted bamboo

Zhuchao Xu^{1,2}, Qiuyi Wang^{1,2}, Xinzhou Wang^{1,2}, Meiling Chen^{1,3}, Yanjun Li^{1,2*}*

¹ *College of Materials Science and Engineering, Nanjing Forestry University, Nanjing, China.*

*andrew@njfu.edu.cn (*Corresponding Author)*

² *National Engineering and Grassland Bureau Bamboo Engineering Technology Research Center, Nanjing, China.*

³ *Forestry Administration, Department of Bio-materials, International Centre for Bamboo and Rattan, Beijing, China.*

Abstract: Reconstituted bamboo, one of the main products of bamboo in recent years, is a novel bamboo-based engineering materials with high utilization ratio of bamboo. However, an effective and feasible method is urgently needed to improve their physical and mechanical properties, dimensional stability and anti-mildew properties. In this study, reconstituted bamboo was made of bamboo bundle irradiated by γ ray. The effect of different irradiation dose (50 KGy–200 KGy) on the properties of reconstituted bamboo was studied thoroughly, including physical and mechanical properties, anti-mildew property. The results showed that the mechanical properties of reconstituted bamboo increased first and then decreased with the increase of radiation dose. Under the condition of irradiation dose at 100 KGy, the modules of rapture (MOR), modules of elasticity (MOE) and the compressive strength parallel to grain direction of reconstituted bamboo reach the maximum of 137.75MPa, 15.01 GPa and 79.24 MPa. Meanwhile, the hygroscopic thickness expansion rate of the reconstituted bamboo decreased with the increase of the irradiation dose. However, the anti-mildew property was dramatically enhanced with increased irradiation dose. As a result, the optimal parameter of irradiation dose is at 100 KGy. Our work provides a novel production process of high-performance bamboo-based engineering materials, which can be used to guide the production in industry.

Keywords: *reconstituted bamboo, irradiation, physical and mechanical properties, mildew resistance*

Research progress on extraction and depolymerization of bamboo hemicellulose: a review

*Wang Meixin, Zhan Yawei, Ma Tengfei, Li Zhiqiang**

Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo &

Abstract: Under the current goal of Carbon Peak and Carbon Neutralization, the development and preparation of high value-added hemicellulose based materials and chemicals have broad application prospects, and these are also of great significance to the sustainable development of human society. However, due to its complex and heterogeneous structure, the research and utilization of hemicellulose are limited, and which has the problems of easy degradation, low yield, difficult purification and high cost. Therefore, how to improve the extraction rate of hemicellulose and its depolymerization products from lignocellulose raw materials has always been the focus of research. In this paper, the research on extraction of hemicellulose and its depolymerization products in recent years is reviewed, different pretreatment methods for extraction of hemicellulose are briefly described, and certain degradation methods are analyzed to obtain depolymerization products of hemicellulose: xylooligosaccharide and xylose. Taking bamboo as an example, it provides constructive suggestions for the development and industrial application of bamboo hemicellulose extraction technology. Finally, combined with the development trend, the development direction of hemicellulose and its depolymerization products in the future is pointed out, especially for the application field of bamboo, which has important theoretical guidance and application value for broadening the utilization of hemicellulose in bamboo.

Keywords: *bamboo, hemicellulose, pretreatment, xylooligosaccharide, xylose*

Facile preparation of chitosan-based composite films with good mechanical strength and flame retardancy.

Huan Liu¹, Jirui Chen², Zenan Zhou³, Wentao Huang⁴, Wenbiao Zhang⁵, Jingda Huang⁶

¹ College of Chemistry and Materials Engineering, Zhejiang A&F University, Hangzhou, China

² China Bamboo Charcoal Museum, Lishui, China

** Corresponding author: zwb@zafu.edu.cn; hjd1015@163.com*

Abstract: To improve the poor water resistance and flame retardancy of cellulose nanofiber (CNF)-based aerogels, chitosan (CS) was used as the reinforcing material, magnesium hydroxide nanoparticles ($\text{nmMg}(\text{OH})_2$) as the flame retardant additive, and polydimethylsiloxane (PDMS) as the hydrophobic agent. CNF/CS/ $\text{nmMg}(\text{OH})_2$ /PDMS composite aerogel was prepared in CNF matrix by low-temperature freeze-drying. CS was used as the linking intermediate to link CNF and $\text{nmMg}(\text{OH})_2$, and the resulting composite film had good flame retardancy. The flame retardant properties of the composite films were greatly improved. The limiting oxygen index (LOI) was increased from 17.5% to 28.7% for CNF aerogel, and due to the ability of $\text{nmMg}(\text{OH})_2$ to produce MgO and water, the ignition point of the aerogel was reduced and a protective MgO layer was formed to block the entry of O_2 . Based on the good flame retardancy, mechanical strength and transparency, CNF/CS/ $\text{nmMg}(\text{OH})_2$ /PDMS composite aerogel has great potential for future applications.

Keywords: cellulose nanofibers, chitosan, non-flammable, hydrophobic, mechanical strength

Experimental investigation on long-term performance of FRP-Glulam - UHPC composite beams

Haolei Wang^{1}, Yuan Tang¹, Yunlei Fan¹, Xiaowei Wang², Wenqian Li¹*

¹ *Central South University of Forestry and Technology, Changsha, China,
wang_haolei@csuft.edu.cn (*Corresponding Author)*

² *Jiazhu Architecture Technology Co. Ltd, Shanghai, China*

Abstract: To improve the long-term performance of conventional timber-concrete composite (TCC) beams, a new TCC structure, namely a fully prefabricated FRP (Fiber-Reinforced Polymer)-glulam-UHPC (Ultra-High Performance Concrete) composite beam was proposed. The composite system is formed by joining a glulam member to a UHPC slab using horizontal steel plate + studs connectors. Aiming to reveal the time-dependent behavior of the proposed structure, a comparative experimental study was conducted on two types of TCC beams, namely one conventional glulam-concrete beam and three glulam-UHPC beams (with or without FRP bars). All specimens were subjected to constant loading in an uncontrolled indoor environment, the ambient temperature and humidity, moisture content of glulam, mid-span deflection, sectional strain and interface relative slip were monitored; and the effects of UHPC and FRP reinforcement, different load levels (13%, 26%) on the long-term behavior of composite system were discussed. The experimental results show that compared with the glulam-concrete specimen, the initial stiffness of the glulam-UHPC composite beam and FRP-glulam-UHPC composite beam was increased by 11.8%, and 25.7% respectively, and the creep coefficient was decreased by 107.4%, 62.8% respectively, suggesting that the application of UHPC can improve the initial stiffness and long-term performance of the TCC beam significantly. The long-term deformation of the FRP-glulam-UHPC specimen increased by 82.3% when the load level was doubled, indicating that the long-term behavior of the TCC composite was not linearly related to the load level. Taking into account wood creep as well as concrete shrinkage creep, a macroscopic long-term deformation calculation model for glulam-UHPC composite beams was proposed. The calculated results of the model fit well with the experimental data and can effectively simulate the long-term deformation trends affected by the ambient temperature and humidity in real situations.

Keywords: timber-concrete composite, ultra-high performance concrete, creep, long-term performance, test

Development of arc laminated giant bamboo using thermally modified segments

J. P. Jimenez, Jr.^{1}, J.E.C. Ramos¹, M.N. Acda²*

¹ *Department of Science and Technology, Forest Products Research and Development*

Institute, Los Baños, Laguna, Philippines

*juanito.jimenez@fprdi.dost.gov.ph (*Corresponding Author)*

² Department of Forest Products and Paper Science, University of the Philippines Los Baños, Laguna, Philippines

Abstract: The lamination of thermally modified giant bamboo [*Dendrocalamus asper* (Schult.) Backer] arc segments was investigated. Two thermal modification treatments were used in this study, viz., steam and hot oil immersion. Lamination of arc shaped bamboo segments was performed with polyurethane resin and assembly consolidated using an arc shaped press mold. Results of the study showed that laminates had reduced hygroscopicity and improved dimensional stability as indicated by a decrease in thickness swelling and water absorption compared to untreated control. Tests for mechanical properties indicated that steam or hot oil treatment had no or little effect on compression, tensile shear strength and modulus of elasticity of the bamboo laminates. Modulus of rupture, however, was reduced significantly with thermal modification conditions used in this study. Orientation of loading (i.e., radial, and tangential) influenced the results of mechanical test of bamboo laminates. In general, the study showed that thermally modified arc bamboo segments can be bonded together forming laminates with improved dimensional stability with little or no effect on mechanical strength properties except for modulus of rupture. The laminates can be further processed to produce bamboo lumber with potential applications as a durable and sustainable material.

Keywords: *arc-lamination, bamboo, Dendrocalamus asper, polyurethane, thermal modification*

Diverse biomaterials from bamboo Argentina

Nancy Lis Garcia¹, Carlos A. Rodriguez^{1}, Mirta Fascio², Norma D'Accorso^{1,2}*

*¹CONICET- Universidad de Buenos Aires, Centro de Investigaciones en Hidratos de Carbono (CIHIDECAR), Buenos Aires, Argentina
nancylis@go.fcen.uba.ar (*Corresponding Author)*

²Universidad de Buenos Aires, Departamento de Química Orgánica, Facultad de Ciencias Exactas y Naturales, Buenos Aires, Argentina

Abstract: Tacuara cane, a specimen Argentine bamboo, is an invasive plant, with only valorization in residential landscapes of ornamental planting in our country. Cellulose, hemicelluloses and lignin were obtained from this cane with a friendly and sustainable procedure. Cellulose nanofibrils were obtained by a green homogenization method and characterized exhibiting a web-like long fibrous structure with the diameter of 10-20 nm. The crystallinity was 65.5%, as for the onset temperature of thermal decomposition was 212 °C. The cellulose nanofibrils (CNF) were efficiently modified to use as charge in the preparation of flexible biodegradable films. The comparison between the films (grafted nanofibrils) with respect to the physic mixture of the components, shows an improvement in the thermal, mechanical, and surface properties of the material. On the other hand, hemicelluloses were used to obtain hydrogels with excellent dye adsorption properties and interesting heavy metal removal properties. The new hydrogels were applied to dye removals, such as rhodamine B,

methylene red and methylene blue in aqueous solutions. The films of lignin with a biodegradable polymer, obtained by electrospinning, can be used as potential scaffolds in biomedicine. Argentine Bamboo is a promising material for obtained new biomaterials with improved properties achieving sustainable low-carbon products and promoting the circular economy

Keywords: *tacuara cane, films, hydrogel, electrospinning, biomaterials*

Biochemical changes of bamboo (*Fargesia yunnanensis*) shoots during storage and the related cold storage mechanisms

Lixia Yu^{1, 2, 3}, Jialong Pei^{1, 2, 3}, Shuguang Wang^{1, 2, 3}*

¹ *Key Laboratory for Sympodial Bamboo Research, Bamboo and Rattan Research Institute, Faculty of Life Sciences, Southwest Forestry University, Kunming, China
stevenwang1979@126.com (*Corresponding Author)*

² *Science and Technology Innovation Team of National Forestry and Grassland Administration, Southwest Forestry University, Kunming, China*

³ *Bamboo and Rattan College, Southwest Forestry University, Kunming, China*

Abstract: The mechanisms for physiological senescence in bamboo shoots after harvest remain unclear. This study investigated physiological changes in *Fargesia yunnanensis* shoots during storage at different temperatures. The relationship between morphological and physiological changes in bamboo shoots during storage was also analyzed. The results show that cold storage can reduce weight loss, browning, respiration rates, and sugar degradation in bamboo shoots; decrease related enzymatic activities; and inhibit the increase in lignin and cellulose content. The quality of bamboo shoots declines more during the first 3 d after harvesting than it does during subsequent periods. The increase in the degree of lignification, fibrosis, and browning is the main reason for senescence and for the decline in quality of bamboo shoots after harvest. Low temperatures had better inhibitory effects on browning than they did on lignification and fibrosis. Nonstructural carbohydrates in bamboo shoots are degraded and flow into sheath and shoot respiration, phenol synthesis, and shoot fibrosis and lignification at room temperature, but only flow into sheath respiration, shoot fibrosis, and lignification at cold temperatures. Soluble protein and free amino acids are primarily distributed into shoot and sheath respiration and into phenol synthesis at room temperature, but that process is well inhibited at cold temperatures. Bamboo shoots, once removed from cold storage, should be consumed rapidly because enzyme activity recovers quickly. This research provides new theoretical information on the preservation of bamboo shoots.

Keywords: *Fargesia yunnanensis shoots, postharvest storage, browning, fibrosis, lignification*

Structural grading of Moso bamboo culm based on its minimum external diameter

Rui Ma, Zhihua Chen, Yansheng Du*, Lingao Jiao

Tianjin University, Tianjin, China

ruima9855@163.com (*Corresponding Author)

Abstract: Bamboo culm has been regarded as a traditional element in construction, meanwhile it has great potential to construct rural houses to achieve green and low-carbon development. However, traditional bamboo houses are usually constructed according to previous experience, and it is hard to design the bamboo houses in a standard way. Structural grading of bamboo culms is an essential work to achieve the standardization design. Grading the Moso bamboo culm based on its minimum external diameter is proposed in this paper. The geometric and physical properties of 653 Moso bamboo culms with three different treatment process was measured and analyzed, namely untreated, with chemical preservatives and heat treatments. It is found that external diameter of Moso bamboo culm could be determined by the perimeter in practice. Treatment process has great influence on the geometric and physical properties. Bamboo culms with three different treatment process could be divided into five, five and four grades respectively. Meanwhile, based on measurement data, the standard design values of each grade are presented, including wall thickness, external and internal taper and linear mass. The study may provide support to establish technical specifications and standard design method of Moso bamboo structural building.

Keywords: Moso bamboo culm, structural grading, standard value

Three-dimensional visualization of the conducting tissue in a bamboo culm base

S. Li^{1,2}, L. Shang¹, Y. Wang², S. Yang^{1*}

¹ International Centre for Bamboo and Rattan, Key Laboratory of National Forestry and Grassland Administration, Beijing, China

yangsm@icbr.ac.cn (*Corresponding Author)

² College of Forestry, Sichuan Agricultural University, Chengdu, China

Abstract: Bamboo is one of fastest growing plants, due in part to its developed culm base root and rhizome system. Conducting tissue within root and rhizome play a key role in the water and nutrient transportation. In this work, a bamboo culm base of *Chimonobambusa tumidissinoda* were imaged using high-resolution X-ray microtomography (μ CT). Deep learning algorithm and watershed algorithm achieved the segmentation of the conducting tissue from the others in the culm base. The nondestructive method was used to characterize the structure of culm base, and three-dimensional (3D) reconstruction of the conducting tissue was realized. The conducting tissue is interlaced in the node of the culm base, with different shapes. Transverse conducting tissue mainly congregated in the rhizome side of the culm base. The

thickness of axial conducting tissue is less than that of transverse conducting tissue at the same cross section of culm base. The thickness of transverse conducting tissue gradually decrease from the bottom of culm base to the top of it, which is contrary to axial conducting tissue. The volume fraction of conducting tissue in the culm base were 6.35%, and the proportion of the conducting tissue ranged between 3.6 and 8.9%. The results showed that μ CT is a fast and nondestructive 3D imaging method for the study of bamboo structure, which provides new insights and understanding of the structure of bamboo culm base.

Keywords: bamboo, culm base, three-dimensional reconstruction, conducting tissue, X-ray microtomography

Cellulose nanofibril/PVA/bamboo activated charcoal aerogel sheet with excellent capture for PM2.5 and thermal stability

Keyu Zhao¹, Changying Ren¹, Youwei Lu¹, Qijun Zhang³, Qiang Wu¹, Siqun Wang^{1,4},
Chunping Dai⁵, Wenbiao Zhang^{1*}, Jingda Huang^{1,2*}

¹ College of Chemistry and Materials Engineering, Zhejiang A&F University, Hangzhou, China

zwb@zafu.edu.cn/jdhuang@zafu.edu.cn (*Corresponding Author)

² College of Biosystems Engineering and Food Science, Zhejiang University, Hangzhou, China

³ Institute of Urban Environment, Chinese Academy of Sciences, Xiamen, China

⁴ Center for Renewable Carbon, University of Tennessee, Knoxville, Tennessee, USA

⁵ Faculty of Forestry, University of British Columbia, Vancouver, Canada

Abstract: Particulate matter (PM) in the air, especially PM2.5, often serves as a pathogen carrier is a serious threat to human health. Filtration is one of the most accessible ways to protect individuals from PM pollution. However, it is still a challenge to prepare air filtration materials with high filtration efficiency and good thermal stability from renewable materials. In this study, cellulose nanofibril (CNF), poly (vinyl alcohol) (PVA), and bamboo activated charcoal nanoparticles (BAC) were used to build an air filtration system with double filtration by simply mixing and freeze-drying. The resulting CNF/PVA/BAC aerogel sheet (3 mm thickness) reached a filtration efficiency of 99.69% for PM2.5 due to its double filtration from the network structure of CNF and electrostatic adsorption of BAC. The composite material also showed high thermal stability with its filtration efficiency over 95% even after exposure to 200 °C for 1h. After modification with MTMS, the hydrophobic CNF/PVA/BAC filtration sheet could be reused for over 5 times by water washing whereby the filtration efficiency remained above 95%, the pressure drops still below 100pa. The environmentally friendliness excellent filtration efficiency and simplistic fabrication make the aerogel sheet a potential material choice to cope with the severe air pollution today.

Keywords: cellulose nanofibril, bamboo activated charcoal, poly (vinyl alcohol), aerogel sheet, pm2.5

Pyrolysis self-activation in vacuum: an environmentally friendly method to transform biowaste into activated carbon and combustible gas

Gao Qi^{1,2}, Feng Zixing^{1,2}, He Yuyu^{1,2}, Hou Yanmei^{1,2}, Ren Hao^{1,2}, Su Mengfu^{1,2}, Ni Liangmeng^{1,2}, Liu Zhijia^{1,2}*

*¹ International Centre for Bamboo and Rattan, Beijing, China
liuzj@icbr.ac.cn (*Corresponding Author)*

² Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China

Abstract: Arsenic is a common pollutant in water, has attracted much attention due to its great toxicity and wide distribution. Activated carbon as an efficient arsenic adsorbent, which preparation process often brings environmental pressure due to the tail gas emission or chemical reagents. In this study, a green method for production of activated carbon and combustible gas was introduced. Bamboo shoot shells were pyrolyzed in vacuum and the H₂O and CO₂ from pyrolysis were used as activators. The specific surface areas of activated carbon can be tuned by controlling temperatures and times, ranging from 373 m²/g to 1855 m²/g. The arsenic adsorption of activated carbon was fitted to the Pseudo-second-order and Langmuir adsorption model, and the maximum adsorption capacity for As (III) and As (V) were 10.88 mg/g and 16.04 mg/g. The thermogravimetric experiments under N₂, H₂O and CO₂ atmospheres were used to simulate the self-activation process and investigate pore development behaviors. The gaseous products from self-activation were innovatively analyzed, which were mainly comprised of CO and H₂ with a HHV of 11.66 MJ/Nm³. This work explained the self-activation mechanism from a new point of view, and evaluated the energy potential of gaseous products. The results will be helpful to improve the competitiveness of self-activation technology and reduce the production cost of activated carbon.

Keywords: *pyrolysis, self-activation, activated carbon, combustible gas, arsenic adsorption*

AFM for macroscopic/microscopic physicochemical properties of biomass materials

Z. Yao, L. Zhichao

*Nanjing Forestry University, Nanjing, China
Zhy97@njfu.edu.cn*

Abstract: Atomic force microscopy is a new microscopy technique that characterizes the three-dimensional morphology and mechanical properties of a sample surface by detecting the probe-sample interaction force. AFM has a wide range of applications in the field of biomass materials because it can reveal the surface structure and mechanical properties of biomass materials in a powerful way. This paper briefly introduces the main components and working principles of AFM, and reviews the current status of AFM applications in biomass materials, including imaging characterization, mechanical characterization and single molecule

recognition imaging of biomass materials. AFM can be used to observe the surface morphology of biomass materials and to analyze their characteristic height and surface roughness. The AFM phase map also provides some surface features that are not available from the height map. The AFM force curve can be used to measure the adhesion between the needle tip and the biomass material, the interaction forces between molecules, and the modulus of elasticity. In addition, AFM single molecule recognition imaging allows for a better quantitative understanding of the mechanisms of cellulose and hydrolase interactions at the single molecule level. In conclusion, AFM has a very promising application in the research and development of biomass materials.

Keywords: *atomic force microscopy, biomass materials, morphological imaging, mechanical characterization, single molecule recognition imaging*

Highly acetylated lignocellulose synthesized from *Neosinocalamus affinis* pretreated by γ -valerolactone/water.

Y. W. Zhan, M. X. Wang, Z. Q. Li

Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, International Centre for Bamboo and Rattan, Beijing, China

Abstract: With the gradual consumption of unrenewable fossil resources and the rapidly growing of the demand for energy resources, the conversion, and utilization of renewable resources have attracted great interest in recent years. In this study, the effect of the γ -valerolactone (GVL)/H₂O pretreatment system on bamboo (*Neosinocalamus affinis*) for was investigated. The performance characterization of the pretreated bamboo substrates, including the chemical composition, the structural characteristics, and the ability to produce cellulose acetate were evaluated. The recovered substrate was modified by vinyl acetate under the catalyst of NaOH at 120 °C for 10 min. For the cellulose in the pretreated bamboo material, the highest cellulose-to-cellulose acetate conversion yield was achieved at 140 °C for 2 h with GVL: H₂O = 8:2, which was 73.39 % with the substitution degree is 2.78, it was 1.8-folds higher than that directly converted from the untreated raw bamboo powder. Under these conditions, 50.60 % of the active lignin can be recovered and be used as a wood-derived feedstock for further high-valued utilization. Meanwhile, the maximum concentration of fermentation inhibitors formed after pretreatment in spent liquor was about 140.9 mmol/L, which had a weak inhibitory to the subsequent reaction. It has been shown that the cellulose could be effectively separated from bamboo and converted into cellulose acetate through the GVL/H₂O pretreatment system.

Keywords: *bamboo, γ -valerolactone pretreatment, cellulose depolymerization, cellulose acetate*

Finite element analysis of the connections between timber beam and steel column with screwed-in threaded rods

H. Tao^{1*}, H. Yang²

¹ School of Civil Engineering, Southeast University, Nanjing, China
230208595@seu.edu.cn (*Corresponding Author)

² College of Civil Engineering, Nanjing Tech University, Nanjing, China

Abstract: The need to increase comfortable living and reduce CO₂ emissions have resulted in a growing interest towards sustainable and ecological buildings like timber structures. To promote the application of high-rise timber structures, innovative timber connections possessing high structural performances have attracted much attention, especially for the connections with screwed-in threaded rods (STRs). Based on the reversed cyclic loading tests on the connections between timber beam and steel column with STRs conducted by Yang et al, this paper aims at establishing the 3D detailed FE models in ABAQUS 6.14 for validation. The 3D elastic-plastic damage constitutive model of the steel and timber were developed to consider the influence of the plastic deformation and damage fracture behavior of the materials. To cover the withdrawal slips and damage of the STRs, the cyclic withdrawal behaviour of the threaded rods was considered by programming the interfacial cohesive elements between the rods and timber holes in ABAQUS. It was demonstrated that the FE model could clearly present all the failure modes of the beam-to-column joint, including the ultra-low cyclic fatigue fracture of steel energy dissipators, the cyclic withdrawal slips of threaded rods, and the compression yield of timber. The FE numerical results also showed good agreement with the test results in terms of the hysteretic performance and the energy dissipation capacity.

Keywords: beam-to-column connection, screwed-in threaded rods, elastic-plastic damage model, cyclic void growth ductile damage model, cohesive element

Determination of amino acids in bamboo juice by UPLC coupled with pre-column derivatization

B. Zhang, C. Ye, J. J. Wang, Y. J. Huang, H. Xun, F. Tang*

Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, International Centre for Bamboo and Rattan, Beijing, China
fengtang@icbr.ac.cn (*Corresponding Author)

Abstract: Bamboo juice is the sap obtained by heating bamboo culm, it is used as expectorant in traditional Chinese medicine. The Amino acid is one of important component in bamboo juice. An ultra-high performance liquid chromatography (UPLC) method was developed for determining amino acids in bamboo juice. Phenyl isothiocyanate was used as a pre-column derivatization reagent. Gradient UPLC separation was performed on ACQUITY UPLC HSS T3 column (2.1×100 mm; 1.8 μm), using 80% (V:V) acetonitrile-water (A), 95% (V:V) 0.1 mol·L⁻¹ sodium acetate-acetonitrile (B) with pH 6.5, and ultrapure water (C) as eluent. The

detection wavelength was 254 nm. The LOQs were 0.49-4.50 µg/mL. The LODs were 0.11-1.8 µg/mL, and the average recovery was 82.10%-125.52% with RSDs ranging from 0.38% to 3.47%. The method was successfully applied to the analysis of the 18 kinds of amino acids in bamboo juice obtained from 35 bamboo species. The total amino acid content ranged from 108.20-3005.33 µg/mL. The juice from *Phyllostachys glauca* had the highest total amino acid content at 3005.33 µg/mL, followed by the juice from *P. robustirama* (2155.99 µg/mL). The top 3 amino acids with the highest average content were found to be aspartic acid (161.28 µg/mL), alanine (98.99 µg/mL), and cysteine (42.54 µg/mL). It is worthy to note that, 8 essential amino acids (EAA) for human beings could be detected in the juice obtained from 15 bamboo species, highlighting the potential nutritive value of bamboo juice. The established method is suitable for the detection of amino acids in bamboo juice.

Keywords: bamboo juice, amino acid, ultra-high performance liquid chromatography

Inhibitory activity of bamboo leaf flavonoids against FabG

H.H. Yuan, X. Yao, H. Xun, J. Wang, F. Tang*

International Centre for Bamboo and Rattan, Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, Beijing, China

*fengtang@icbr.ac.cn (*Corresponding Author)*

Abstract: Fatty acid synthase (FASN) is a key enzyme involved in the endogenous fatty acid synthesis. The overexpression of FASN can be commonly observed in multiple types of cancer cells. The development of FASN inhibitors from natural products has become a hot topic in the research of cancer therapy. The inhibitory effect of crude bamboo leaf flavonoids on FASN and human breast cancer (MDA-MB-231) cells has been discovered in our previous works, however, the active flavonoids compounds have not been identified, and the inhibitory mechanism has not been fully elucidated. FabG, an NADPH-dependent β -ketoacyl-ACP reductase, is an essential and universally expressed component of type II fatty acid biosynthesis. In this study, FabG was selected as the research subject to explore the inhibitory mechanism of bamboo leaf flavonoids on FASN. FabG was extracted and purified from a gene sequence synthesized FabG-rich recombinant *E. coli* strain, and the enzymatic activity of FabG was determined by GC-MS. After a comprehensive screening, 14 bamboo leaf flavonoids showed good inhibitory effects on FabG. The inhibition rates of Isovitexin, Isoginkgetin, Ginkgetin, Luteolin, Naringenin, Kaempferol and 8-formyl ophiopogonanone B at a concentration of 100 mg/L were 96.92%, 97.70%, 93.79%, 100%, 96.23%, 100%, and 90.89%, respectively. This study provided important references and a promising strategy for the development of FabG inhibitor from bamboo natural products.

Keywords: fatty acid synthase, bamboo leaf flavonoids, inhibitor

Application of modified atmosphere packaging and biological preservatives in the preservation of TianLong bamboo (*Dendrocalamus brandisii*) shoots

*F. Qiu, Y.J. Huang, X. Yao, H. Xun, J. Wang, F. Tang**

International centre for Bamboo and Rattan, Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, Beijing, China

*fengtang@icbr.ac.cn (*Corresponding Author)*

Abstract: TianLong bamboo (*Dendrocalamus brandisii*) shoot produced in Yunnan Province is famous for its distinctive sweet taste. Being rich in soluble sugar and protein, the TianLong bamboo shoots are prone to oxidation and browning in the process of transportation, leading to changes in appearance and smell, which may seriously affect the edibility of bamboo shoots. This research presented a preservation technology for Tianlong bamboo shoots at room temperature using modified atmosphere packaging gas and biological preservatives. The fresh-keeping effects of the volume ratio of N₂, O₂, and CO₂ in the modified atmosphere packaging and the treatment concentration of biological preservatives, including tea polyphenol, lactic acid streptococin, water-soluble chitosan, and lysozyme, were evaluated. The sensory index, weight loss rate, contents of crude fiber, water-soluble sugar, and protein in the bamboo shoots were monitored for evaluating the optimal gas ratio and biological preservatives concentration. The results showed that the gas ratio of 50% CO₂ and 50% N₂ and 500mg·L⁻¹ tea polyphenols could effectively inhibit oxidative browning of the Tianlong bamboo shoots, reduce weight loss, inhibit the decomposition of water-soluble sugars and proteins, and lignification. This research provides a reference for reducing the transportation loss, and extending the shelf life of Tianlong bamboo shoots.

Keywords: *TianLong bamboo shoots, preservation, modified atmosphere packaging, biological preservative*

Chemical composition and biological activity of pressurized hot water extracts from Moso bamboo (*Phyllostachys pubescens*) culms

Y. Yang^{1†}, J.H. You^{1†}, H. Xun¹, X. Yao¹, J. Wang¹, F. Tang^{1}*

¹ International centre for Bamboo and Rattan, Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, Beijing, China

*fengtang@icbr.ac.cn (*Corresponding author)*

† These authors have contributed equally to this work and share first authorship.

Abstract: In recent years, bamboo pulping products, especially bamboo pulping tableware and packaging materials have developed rapidly. However, the waste liquor produced in the pretreatment section has not been well utilized yet. In this study, Moso bamboo culms were extracted with pressurized hot water to simulate the pretreatment process of bamboo pulping.

The extraction parameters were optimized, the chemical composition of the extracts was analyzed using GC-MS and HPLC, and the potential biological activities were evaluated. The highest yield of dry matter (12.44%) was achieved when 4-year-old Moso bamboo culms were extracted with water at the solid-liquid ratio of 1:12.5 for 30min at 165°C. In total 22 chemical components were detected by GC-MS, including 17 phenolic compounds, 4 ester compounds, and 1 furan compound. And 3 chemical components were determined by HPLC, which were coniferyl alcohol, p-Hydroxy-cinnamic acid, and syringaresinol. The extract obtained at 220°C showed good antioxidant activity in a DPPH assay, the IC₅₀ value was 11.97 mg/mL, which was better than the positive control of BHT, and the inhibitory activity against fungi was also observed from the extracts obtained at temperatures above 200°C. The results of this research presented scientific data on chemical composition and biological activities of pressurized hot water extract of Moso bamboo culms, and also provided a theoretical basis for the utilization of bamboo-derived active natural products in the waste liquor from the manufacturing of bamboo pulping.

Keywords: bamboo pulping, Moso bamboo culms, pressurized hot water extraction, chemical composition, biological activity

Effect of bamboo shoot dietary fiber with different solubilities on the *in vitro* digestion and gut microbiota metabolism.

Jiong Zheng^{1*}, Hongzhou Zhao¹, Nan Wang¹, Fusheng Zhang¹, Liangru Wu²

¹ Southwest University, Chongqing, China

zhengjiong248@163.com (*Corresponding Author)

² China National Bamboo Research Center, Hangzhou, China

Abstract: The digestive and fermentation characteristics of the three BSDFs, including soluble dietary fiber (SDF), insoluble dietary fiber (IDF), and total dietary fiber (TDF) were different. All three different BSDFs exhibited resistance to gastrointestinal digestion, and SDF had the lowest degree of hydrolysis and exhibited the greatest resistance to digestion during *in vitro* gastric and intestinal digestion. DF with different solubility resulted in different SCFA results during *in vitro* fermentation, and SDF produced higher SCFA content than IDF and TDF within 24 h. During fermentation, Ara, Gal, Glc, Gal-UA, and Xyl in SDF were consumed by the gut microbiota to increase the content of total SCFA production, especially acetic acid and butyric acid. By contrast, Glc, Ara, and Man in IDF were consumed to produce more propionic acid. All three BSDFs can increase the relative abundance of specific beneficial bacteria in the gut. Among them, SDF increased the relative abundance of microorganisms such as *Blautia*, *Collinsella*, *Bifidobacterium*, and *Lachnoclostridium*, whereas IDF and TDF increased the relative abundance of *Escherichia Shigella*, *Citrobacter*, and other microbiota. Furthermore, SDF played a key role in the probiotic effect of BSDF. The comparison of the digestive and fermentation characteristics of SDF, IDF, and TDF provided valuable information on the absorption, utilization, and metabolism patterns of BSDF in the human gastrointestinal tract. These results provided insight into the relationship between BSDF and the gut microbiota, which promoted the understanding of BSDF metabolic processes and probiotic properties.

Keywords: bamboo shoot dietary fiber, in vitro digestion, in vitro fermentation, monosaccharides, gut microbiota

A novel mechanical kiln for bamboo molded charcoals manufacturing

*Liangmeng Ni, Zhijia Liu**

International Centre for Bamboo and Rattan, Beijing, China

17346610822@163.com

*Liuzj@icbr.ac.cn (*Corresponding author)*

Abstract: To upgrade the industrial techniques of bamboo molded charcoals (BMCs), a novel mechanical kiln was designed with the new heating method, high pyrolysis efficiency, and reuse of self-release gaseous. In this research, BMC-1 and BMC-3 were produced by novel mechanical kiln with pyrolysis temperature 650 °C (5090 min) and 389°C (5430 min). BMC-2 was produced by brick kiln with pyrolysis temperature 680 °C (22505 min). Proximate and kinetic analyses, Cone Calorimetry, and X-ray fluorescence were used to investigate the energy properties and ash fusion characteristics of BMCs. It was concluded that the efficiency of novel mechanical kiln was increased by 320.44%, compared with brick kiln. The physical and mechanical performs of BMCs were improved by novel mechanical kiln. The ash, fixed carbon and moisture content of BMC-1 and BMC-3 met the requirements of EN 1860-2:2005. All BMCs had a stable combustion process, but BMC-1 and BMC-3 owned a higher reactivity and a lower mean yield of CO (1.78 kg/kg) and CO₂ (15.12 kg/kg). In addition, the novel mechanical kiln increased the content of SiO₂ and reduced the content of alkali metal in ash samples, resulting in variation of fusion characteristics and reducing the risk of fouling. These findings will be helpful to provide a scientific guidance to optimize the manufacturing process of BMCs.

Keywords: bioenergy, solid biofuel, bamboo molded charcoal, pyrolysis kiln, energy properties

Development of bamboo standards in Colombia

J. Hurtado

Icontec, Bogotá, Colombia

jhurtado@icontec.org (Corresponding Author)

Abstract: Since 2002, Colombia began working on the preparation of normative documents that will contribute to the competitiveness of guadua and its products, through the technical committee for standardization no. 178 “Bambú-Guadua”. The most important species of woody bamboo in Colombia is guadua, and the main use that has historically been given to it has been in construction, either with elements from it to build cemented bahareque houses, or with

complete culms to build structures. However, the normalization of guadua has not been limited to its use in construction, to date there are standards and guides related to agricultural, botanical, ecological, construction, furniture and handicrafts uses, among others. It should be noted that the Colombian earthquake resistant construction regulation, in 2010 incorporated the guadua structures in it, which, in turn, refers to various Colombian Technical Standards (NTC, by its acronym in Spanish) for guadua.

Bamboo standards aim to facilitate domestic and international trade in bamboo products, as well as promote the sustainable use of bamboo resources. In the aspects of sustainability, bamboo plays a positive role because it contributes to the achievement of several of the UN Sustainable Development Goals (SDGs), such as the end of poverty, the supply of affordable and clean energy, the promotion of sustainable cities and communities, responsible consumption and production and, above all, providing effective and eco-friendly solutions to mitigate climate change.

Keywords: *bamboo, Guadua, culm, construction, sustainability*

Efficient separation and structural changes of primary lignin in bamboo at different growth stages

S. Yang^{1}, X. Yang¹, J. Qi², Q. Wang³*

¹ *International Centre for Bamboo and Rattan, Beijing, China*
*yangsm@icbr.ac.cn (*Corresponding Author)*

² *Sichuan Agricultural University, Chengdu, China*

³ *Beihua University, Changchun, China*

Abstract: Molecular structure of lignin is one of the factors that determine the performance of bamboo, and it is the key and difficult basic research in anatomy and chemistry of bamboo. In this study, bamboo with different growth stages was used as raw material for lignocellulose, and a new type of original lignin was obtained based on ball milling and enzymatic hydrolysis. The obtained samples were combined with Fourier Transform Infrared (FTIR) spectroscopy and the 2D HSQC NMR to study the structural changes of lignin. The results showed that bamboo lignin belongs to typical GSH-type, and the γ -position of the side chain has a certain degree of acylation mainly coming from the esterified p-coumaric acid. The main connecting bonds contained in lignin of different bamboo ages were β -O-4 linkages. The lignin signal is relatively complete for bamboo at four ages. With the increase of bamboo age, the S/G value of lignin increases, and the content of H-type lignin tends to be stable in adult bamboo. In addition, the content of β -O-4 was positively correlated with the S/G value. This study analyzed the chemical structure characteristics of lignin in moso bamboo from the molecular level, made up for the lack of structural research on the chemical components of bamboo cell walls, and provided a theoretical basis for the high-value utilization and processing technology of moso bamboo.

Keywords: *moso bamboo, lignin, component separation, structural characterization*

The microstructure and lignin distribution of parenchyma cell wall in developmental bamboo culm

C. Liu¹, E. Xiang^{1,2}, S. Yang^{1*}, X. Liu¹, L. Shang¹, G. Tian¹, J. Ma¹, Q. Ma¹

¹ Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, International Centre for Bamboo and Rattan, Beijing, China
yangsm@icbr.ac.cn (*Corresponding author)

² Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing, China

Abstract: Bamboo parenchyma is responsible for absorption, storage, assimilation, and other nutritional functions. The structure and heterogeneous distribution of lignin in parenchyma is one of the factors that determine the performance of bamboo. The microstructure and lignin distribution in parenchyma cell wall for developing *Phyllostachys edulis* was investigated by means of various high-resolution electron microscopes. The main anatomical characteristics of *P. edulis* in different growth stages were significantly affected by culm age. The wall thickness of parenchyma cells was 2.49-11.24 μm . The lumen diameter of the parenchyma cell gradually decreased, while the double cell-wall thickness and its ratio increased, and the number of cell wall layers increased continuously with bamboo age. The thickness of the narrow layer in the secondary wall of parenchyma cells is 100-300 nm, and the thickness of the broad layer is 300-900 nm with small thickness difference. Lignin continued to accumulate in the cell wall with culm age. Within a single cell, lignin was first deposited in the CC and CML regions, and then toward the secondary wall. There were differences in the content of lignin units. The absorbance of G units and p-hydroxycinnamic acid in different types of cells were both higher in CC and CML regions than in SW regions. The results will provide important reference value for further study of the biological formation mechanism of bamboo.

Keywords: bamboo culm, parenchyma, microstructure, lignin distribution

Determination of chemical changes in bamboo due to degradation by brown and white rot fungi

X. Ziqiao¹, Z. Bo², W. Yangao², Y. Shumin^{1*}

¹ Key Laboratory of Bamboo and Rattan Science & Technology, State Forestry Administration of China, International Centre for Bamboo and Rattan, Beijing, China
yangsm@icbr.ac.cn (*Corresponding author)

² Sichuan Agricultural University, Chengdu, China

Abstract: Biological pretreatment of lignocellulosic plant cell wall draws increasing attention due to its advantages of being environmental friendly, less energy consumption and fewer by-products. However, the mechanism of the biodegradation of cell walls are not fully understood. In order to explore the chemical changes in moso bamboo (*Phyllostachys edulis*) due to microbial degradation, 4.5-year-old moso bamboo was degraded by brown rot fungi (*Gloeophyllum trabeum*) and white rot fungi (*Coriolus versicolor*). The chemical composition

was determined with reference to the relevant standards, and X-ray photoelectron spectroscopy (XPS), X-ray diffractometer (XRD) and Fourier transform infrared spectroscopy (FTIR) are applied to investigate the elemental composition, relative crystallinity and functional groups of bamboo cell wall at different stages of biodegradation. The results show that the fungal degradation of cell wall is a complex process. The degradation of each chemical component by fungi is carried out simultaneously, but their rates are different. After 16 weeks of biological pretreatment, the relative content of cellulose in the cell wall decreased less than that of hemicellulose, lignin and ethanol extraction. White rot fungi had a stronger degradation effect on lignin, and degraded S lignin more preferentially. During pretreatment, relative crystallinity changed with the degradation of crystalline cellulose and other amorphous substances by fungi. The crystallinity of bamboo treated with brown and white rot fungi increased after 16 weeks. This study characterized the chemical changes in moso bamboo due to biodegradation, which will provide a reference for the efficient utilization of lignocellulose and bioconversion.

Keywords: *moso bamboo, biodegradation, chemical analysis, cell wall, biological pretreatment*

Quantitative structural analysis of bamboo lignin during p-TsOH pretreatment

Q. Yang¹, X. Yang^{1,2}, J. Qi², S. Yang^{1}*

¹ *Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, International Centre for Bamboo and Rattan, Beijing, China*
*yangsm@icbr.ac.cn (*Corresponding Author)*

² *Sichuan Agricultural University, Sichuan, China*

Abstract: The p-toluenesulfonic acid (p-TsOH) co-dissolving system can achieve green separation of lignin due to its low toxicity and good solubility, but the separation mechanism is not very clear. Hydrothermal treatment was used to selectively break the bond between lignin and hemicellulose in moso bamboo of different ages to remove hemicellulose. In this study, the bamboo powder after hydrothermal treatment was pretreated with different concentrations of p-TsOH solution, and the change of lignin structure during the pretreatment process was studied. The results showed that the contents of lignin increased with the increase of p-TsOH dosage, and 5-year-old bamboo has the highest lignin yield of 31.99% when the dosage of p-TsOH reaches 80%. The lignin structure was destroyed with 80% p-TsOH. In addition, p-TsOH showed some recoverability in the recovery experiment at 40% concentration. Under the same concentration of p-TsOH solution, the contents of lignin increased with the increase of bamboo age. The two-dimensional NMR results showed that, the content of β -5 increased gradually, while the content of β -O-4 and β - β decreased with the increase of moso bamboo age under the same treatment conditions. The Results will support theoretical basis in field of pulp and paper, biomass conversion, carbon-based nano material and modification.

Keywords: *moso bamboo, p-Toluenesulfonic acid, pretreatment, structural analysis*

Effective flange width evaluation for timber-concrete composite beams with crossed inclined coach screw connections at the serviceability state

H. Yang^{1*}, H. Tao²

¹ College of Civil Engineering, Nanjing Tech University, Nanjing, China
hfyang@njtech.edu.cn (*Corresponding Author)

² School of Civil Engineering Southeast University, Nanjing, China

Abstract: Timber-concrete composite (TCC) structures, taking advantages of the good tension properties of timber and the high compression behaviour of concrete, increasing comfortable living and reducing CO₂ emissions, contributes a new development prospect of sustainable multi-story and high-rise timber structures. In this study, the effective width of the TCC beams with crossed inclined coach screw connections at the serviceability state was evaluated to support the design and application of TCC floor systems. The shear lag effect in concrete slab was discussed by the bending tests on the TCC beams with different slab widths. A parametrical nonlinear finite element (FE) analysis for the TCC beams was conducted based on ABAQUS 6.14. The test results demonstrated that the shear lag effect was more apparent for the tension strain at the bottom of concrete slab than the compression strain at the upper surface of slab. The FE numerical results showed high agreement with the test results in terms of the failure modes, stress-strain, load-deflection, load-slip behaviour of the TCC beams. The parametrical studies indicated that the effective width of TCC beams mainly depends on the load type, slab width-to-span ratio, slab thickness, and connection stiffness. Based on the numerical parametrical analysis, a general formula was finally proposed to calculate the effective width of the TCC beams in practical engineering.

Keywords: effective slab width, timber-concrete composite beams, bending test, finite element model, parametrical analysis

A comprehensive study of lignocellulosic nanofilm from bamboo via acid hydrotropic fractionation

W. Kun, L. Xinge, Y. Shumin, M. Jianfeng, T. Genlin, S. Lili, J. Zehui,
M. Qianli*

Department of Biomaterials, International Centre for Bamboo and Rattan,
Beijing, China

maql@icbr.ac.cn (*Corresponding Author)

Abstract: The lignocellulosic nanofibrils (LCNF) were produced by recyclable aromatic acid, under mild condition and the. Bamboo chips were hydrolyzed with *p*-toluenesulfonic acid (*p*-TsOH) followed by mechanical processing. The temperature of hydrolysis process was below 90°C with the concentration of 20 wt% to 70 wt%. The combined delignification factor (CDF) and combined hydrolysis factor (CHF) were introduced to elucidate the effect of different hydrolysis conditions. After optimal selection, lignin can be dissolved up to more than 60%,

while xylan was about 70%. The resultant LCNF exhibited uniform distribution with the diameter of 20-90 nm and unchangeable surface functional chemical groups, so that activity properties of LCNF were preserved. The better thermal stability ($T_{max} > 350^{\circ}\text{C}$) of the LCNFs were also obtained. Furthermore, the films made by the LCNFs possessed strong UV-blocking properties which can block more than 99% of UV rays. In addition, LCNF films presented high contact angle (water, $89\text{-}99^{\circ}$) and maintained at $56^{\circ}\text{-}64^{\circ}$ after 300 seconds which showed the great water resistance. In general, LCNF can be easily obtained from bamboo chips by *p*-TsOH hydrolysis process and can be prepared as a nano film with excellent properties, which can provide a feasible route for high-value applications

Keywords: *lignocellulosic nanofibrils, p-toluenesulfonic acid, films, UV-blocking, water resistance*

Directional bamboo laminated lumber: a new material with infinite lengthening

Qiuqin Lin¹, Ru'nan Gao², Daohao Li³, Hui Lu¹, Yanglun Yu¹, Yuxiang Huang^{1}, Wenji Yu¹*

¹ *Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing, China
yxhuang@caf.ac.cn (*Corresponding Author)*

² *Northeast Forestry University, Harbin, China*

³ *Qingdao University, Qingdao, China*

Abstract: With the growing desire for environmental friendliness, biomass-based composites made from natural resources are greatly in demand as the sustainable and recycle materials for large-span construction and engineering. In this work, directional laminated bamboo lumber (DLBL) is manufactured with bamboo strips after lengthening with joints. Three types of joint shapes for lengthening bamboo strips are explored with three layered DLBL, and the effects of quantities and locations on bending performance of the DLBL are further evaluated. The results show that the reduced rate of bending strength of LBL with three types joints are all exceed 10%. However, the simpler and more efficient process of machining and gluing made hook joint the most potential choice for bamboo strip lengthening. Based on optimizing joint shape, the reduced rate of strength attained minimum (1.43%) when the hook joint is located at the 1/4 length of the sample. As increasing the joint quantity from 1 to 3, the bending strength decreased by 6.82–31.11%. It appeared that the parameters of joint have a great influence on the strength of DLBL and it is important to control the quantities and locations of the joint. By optimizing the joints, DLBL with infinite lengthening can be widely applied as large-span structural materials, contributing to the a sustainable and environment-friendly society.

Keywords: *bamboo laminated lumber, large span building materials, joint, strength, fabrication*

Effect of multi-cycle artificial accelerated aging on physical and mechanical properties of bamboo scrimber

Yue Qi, Wencheng Lei, Wenji Yu, Yahui Zhang*

University Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing, China
zhangyhcaf@163.com (*Corresponding Author)

Abstract: Artificial accelerated aging for bio-materials is an important test to evaluate the degradation mechanism, to understand dimensional and mechanical changes, and to establish the predict model. Bamboo scrimber as a new kind of bio-composites, has been widely used in the field of architecture, outdoor flooring and door or window. Thus, multi-cycle artificial accelerated aging process of bamboo scrimber is to identify various stages of changes in dimensional stability and selected mechanical properties. The determination methods, with 28h water boiled cycle of 100 °C, 672h water immersion of fresh water or seawater of 63°C, and the cycle of boiling-freezing-drying, were applied in this study. For dimensional stability, the swelling results of bamboo scrimber could be predicted with different test methods. In particular, the density has significantly affected the dimensional stability, which proved that the swelling ratio of samples decreased as increasing density of bamboo scrimber. Further, the swelling ratio was sharply increased at the initial stage, and then tended to be stable at the aging periods. For mechanical properties, bending, tensile, compressive and shear strength were analyzed by loss ratio. As increasing accelerating time, the loss ratio performed notably and then kept in stable stage for both mechanical determinations. It is remarkable that the reservation of mechanical strength was arrived at higher level even if the density and resin content was the lowest. Overall, the evaluation of dimensional stability and mechanical properties of bamboo scrimber is contributable to application in the different fields.

Keywords: artificial accelerated aging, bamboo scrimber, dimensional stability, mechanical properties

Preparation of ultra-small CDs from common lophatherum herb and its fluorescence mechanism and application in anti-counterfeiting and cell imaging

Hu Miaoyan^{1,2,3}, Xu Changyan^{1,2,3*}

¹ College of Materials Science and Engineering, Nanjing Forestry University, Nanjing, China

² Co-Innovation Center of Efficient Processing and Utilization of Forest Resources, Nanjing Forestry University, Nanjing, China

³ Jiangsu Key Lab of Biomass-Based Green Fuels and Chemicals, Nanjing Forestry University, Nanjing, China

changyanxu1999@163.com (*Corresponding Author)

Abstract: Biomass CDs have good photoluminescence, fluorescence stability and biocompatibility, low cost of raw materials, green environmental protection, and broad

application prospects. The physical and chemical properties of CDs are closely related to the precursor, preparation method and preparation process. However, there are few researches on the preparation process optimization and photoluminescence mechanism of CDs at this stage, which greatly limits the controllable synthesis and practical application of carbon dots. application. In this study, common lophatherum herb rich in heteroatoms (N, Si) and small molecule fluorophores (benzoheterocycles) were used as precursors. The response surface method was used to optimize the hydrothermal preparation of CDs with the fluorescence quantum yield (QY) as the response value. Through TEM, Abs, etc. characterization and DFT theoretical calculation, the optimal preparation process, molecular structure and fluorescence mechanism of CDs were determined. In addition, through inkjet printing and cytotoxicity experiments, it is proved that the CDs have application potential in the fields of fluorescence anti-counterfeiting and cell imaging. The research results help to interpret the fluorescence mechanism of Ultra-small CDs and customize the Ultra-small CDs according to the needs of the application, and provide a new way for the high-value utilization of common lophatherum herb.

Keywords: *common lophatherum herb, response surface method, ultra-small CDs, fluorescence mechanism, fluorescent anti-counterfeiting*

Study of the long-term degradation behavior of bamboo scrimber under natural weathering

*Yahui Zhang¹, Hongxia Ma², Yue Qi¹, Rongxian Zhu¹, Xingwei Li², Fei Rao³,
Wenji Yu^{1*}*

¹ *University Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing, China*

*chinayuwj@126.com (*Corresponding Author)*

² *Guangdong Academy of Forestry, Guangzhou, China*

³ *Department of Industrial Design, School of Art and Design, Zhejiang Sci-Tech University, Hangzhou, China*

Abstract: Bamboo scrimber as a new kind of bio-composite, the physical and chemical properties are changed due to environmental factors through different mechanism for outdoor use. It is demand to explore the process of natural weathering system for evaluation of bamboo scrimber safety urgently. Because of the singularity of laboratory accelerated weathering and complexed natural environmental conditions, the researches on the weathering characteristics and degradation mechanism of bamboo scrimber need to be determined exposing at the natural environment.

In order to evaluate degradation behavior and mechanism of the surface, the bamboo scrimber samples were exposed for ten years at different typical climatic situations, with same parameters, including determination method, samples dimensions, and observation cycle. The results showed that the lignin on the surface of the bamboo scrimber underwent photodegradation during exposure time, while the surface became rich in cellulose. The surface color changed significantly, especially during the first two years of weathering, and then kept

stable state of grey color due to the lignin being washed with rainwater. The change of transverse surface was significantly different within weathering period, with micro-crack appeared in fiber cell and parenchyma cell due to lignin degradation. Remarkable differences were found among various climatic regions, which is attributable to different temperature, humidity and sunshine duration. These findings demonstrated that the weather resistance of bamboo scrimber in the different regions, and were contributed to design and develop the manufacturing parameters of bamboo scrimber that could be suitable for diverse utilizations.

Keywords: *bamboo scrimber, degradation behavior, different environment, natural weathering*

Research on multi-sensor fusion technology for crack monitoring of historical timber structure based on digital twins

Wu Ying¹, Li Aiqun^{2,3}*

¹ School of Science, Beijing University of Civil Engineering and Architecture, Beijing, China

² School of Civil and Transportation Engineering, Beijing University of Civil Engineering and Architecture, Beijing, China

*liaiqun@bucea.edu.cn (*Corresponding Author)*

³ School of Civil Engineering, Southeast University, Nanjing, China

Abstract: Theoretical developments have revealed that the most common damage form of historical timber structure is crack. Moreover, the main components of historical timber structure, including columns, beams, rafters and bucket arches, are often cracked and damaged, which affect mechanical properties and durability of wooden structure, seriously threatening health and stability of historical timber structure. Based on BIM technology, this paper develops a multi-sensor fusion digital twins platform suitable for crack monitoring of historical timber structure. The digital twin platform includes vector analysis, attribute transformation and standard model base construction representing the cracking data of wood structures. After collecting multi-dimensional data of wood structure cracking, vector analysis is carried out, and identification algorithms such as principal component analysis and Bayesian method are used to convert the attributes of wood structure cracking. Finally, edge operation is used to integrate the sensor data monitoring wood structure cracking. Based on digital twins platform, it could realize the integration of preventive protection monitoring data, basic information data, cultural relics safety supervision data and digital protection data for crack in historical timber structure, making digital protection of ancient building move towards a high-level digital twins building. Finally, the feasibility of the proposed multi-sensor fusion digital twins platform for crack monitoring of historical timber structure is verified by a northern historical timber building model.

Keywords: *historical timber structure, digital twins, structural damage*

Bamboo -- the potential source for livelihood enhancement and hunger eradication

Vidya R. Sankar ^{1,2,3,4}

¹Kerala Agricultural University, Kerala, India

²Expert Member, Taskforce on Sustainable Bamboo Forest Management, INBAR

³Expert Member, Taskforce on Bamboo Nutrition, INBAR

⁴Former Research Associate at Kerala Forest Research Institute, Kerala, India

vidyarsankar@gmail.com (Corresponding Author)

Abstract: The grass with tremendous potential, bamboo has a significant role in raising the living standards of the associated communities. Among the wide array of applications, edible bamboo shoots have been the products of delicacy for ages, and around more than 300 species were identified as palatable. High dietary fiber and minerals with low-fat content made it an ideal vegetable. Proper processing and storage of these shoots in containers helped to shipped worldwide irrespective of seasons. Here we explored some simple and cost-effective processing and storage methods without losing quality.

Common species in India viz. *B. balcooa*, *D. asper*, *D. giganteus*, *M. baccifera*, *O. travancorica*, *P. ritcheyi* and *T. oliveri* were selected. Boiling in water or in different concentrations of NaCl for various intervals and drying after boiling in Sunlight (SD), Oven (OD), and Microwave (MWD) were tried. The effect of boiling in NaCl was found to be species-specific whereas boiling in water in closed containers retained the texture and taste of shoots for more than 1.5 years at different temperatures. The MWD was quickest (4 hrs.) whereas SD took 35 hrs. with a comparable rehydration ratio of OD sample with SD samples. SD retained the natural appearance whereas non-enzymatic browning cause browning in other treatments. Drying methods aid in better utilization of the fibrous region after powdering. All these methods were found to be useful for adoption at a household level, and are expected to provide an additional source of earnings for bamboo farmers and small-scale shoot processing industries.

Keywords: bamboo edible shoots, shoot processing, brine preservation, drying

Simultaneous determination of 25 phenolic compounds in extracts of *Bambusa chungii* bamboo culm by UPLC-Q-TOF-MS

J.J. Wang[†], X.S. Cao[†], H. Xun, X. Yao, J. Wang, F. Tang^{*}

International Centre for Bamboo and Rattan, Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo & Rattan Science and Technology, Beijing, China

fengtang@icbr.ac.cn (*Corresponding Author)

[†] These authors have contributed equally to this work and share first authorship

Abstract: Previous studies have validated that, phenolic compounds, especially flavonoids and phenolic acids are the main contributors to the antioxidant capacity of bamboo extracts. A LC-Q-TOF-MS method for simultaneous determination of 25 phenolic compounds in *Bambusa chungii* bamboo culm was developed. 25 phenolic compounds were separated on a C18 column (2.1×150 mm, 1.8 μm), Gradient elution solvent was set up as 0.1% (v/v) formic acid in water (solvent A) and acetonitrile (solvent B) at a flow rate of 0.25 mL/min, temperature 40 °C and injection volume 2 μL. Mass spectrometry conditions source parameters were fixed as follows for the positive mode: electric spray ion source, capillary voltage, 4500 V; electric spray voltage, 3500 V; ion source temperature, 350 °C; drying temperature, 350 °C; dry gas flow, 7 L/min; sheath flow, 11 L/min; atomizing gas pressure, 35 psi; nozzle pressure, 1000 V; collision voltage, 40 V. Scan range was set between 50 and 800 m/z. The LOQs were 0.08-10.85 mg/L, the LODs were 0.02-4.50 mg/L, and the average recoveries were 82.22-107.21% with RSDs ranged from 0.77% to 8.64%. Using the established detection method, 8, 14, and 7 phenolic acids were successfully qualified and quantified in the bamboo culm extracts obtained from 3 extraction methods of maceration with ethanol, ethanol reflux extraction, and hot water extraction, respectively. This method is suitable for determining phenolic compounds in bamboo culm extracts. The results showed the effects of extraction methods on phenolic content in the bamboo culm extracts of *Bambusa chungii*.

Keywords: bamboo culm extracts, Uplc-q-tof mass spectrometry, phenolic compounds, *Bambusa chungii*

Microfibril orientation of the secondary cell wall in parenchyma cells of *Phyllostachys edulis* culms

Caiping Lian¹, Jing Yuan², Junji Luo², Shuqing Zhang², Rong Liu², Hong Chen¹, Xuehua Wang¹, Mingxin Cao¹, Zhihui Wu^{1*}, Benhua Fei^{2*}

¹Nanjing Forestry University, Nanjing, China

²International Centre for Bamboo and Rattan, Beijing, China
wzh550@sina.com; feibenhua@icbr.ac.cn (*Corresponding author)

Abstract: The secondary cell wall of bamboo parenchyma cells is microfibril-based. However, understanding of the microfibril orientation of secondary cell walls in bamboo parenchyma cells is lacking. This study characterized the microfibril orientation of the sub-layers of the secondary cell wall in the parenchyma cells by field-emission environmental scanning electron microscopy and the microfibril angle of the ground parenchyma cell wall with X-ray diffraction. The microfibril orientation of tight-loose alternating layers of the secondary cell wall was in the opposite direction along the longitudinal axis. Near the parenchyma cells' pit aperture, the microfibril orientation generally bypassed the pits and continued in a flow-like pattern. The mean microfibril angle of ground parenchyma cells was 63.3°. The average microfibril angle of adjacent sub-layers of the secondary cell wall was 60° and -65° in ground parenchyma cells, and 54° and -52° in vascular parenchyma cells. A structure model of microfibril orientation of parenchyma cell wall in moso bamboo was firstly constructed. The study provides insight into the anatomical structure of the parenchyma cell wall in the bamboo

plant. Moreover, it provides a structural basis for further analysis of the mechanical properties of parenchyma cells. (Lian et al., Cellulose, 2022)

Keywords: moso bamboo, parenchyma cells, secondary cell wall, microfibril orientation, microfibril angle

Effect of bending on radial distribution density, MFA and MOE of bent bamboo

Xuehua Wang¹, Jingwen Ma¹, Wei Xu¹, Benhua Fei², Caiping Lian^{1}, Fengbo Sun^{2*}*

¹ Nanjing Forestry University, Nanjing, China

² International Centre for Bamboo and Rattan, Beijing, China

wangxuehua@njfu.edu.cn (Corresponding Author)*

Abstract: One of the excellent characteristics of bamboo is the deformation stability. However, the reasons for the good bending stability of bamboo have not been well studied. In this study, we examined the pathways that controls bending deformation in bamboo. A hand-bent *phyllostachys iridescens* member was chosen to examine continuous density distribution, microfibril angle (MFA) and modulus of elasticity (MOE) along radial direction using SilviScan analysis. Our results show that in bent bamboo, MFA is lower in tension sample and higher in compression sample than neutral sample. There is a strong linear positive correlation between density and MOE, while negative linear correlation between MOE and MFA and no obvious linear correlation between MFA and density. Increased bending was influential in primarily changing the MOE, while also altering the density distribution and MFA. Our results demonstrate variation in density, MOE and MFA distribution along radial direction of tension, neutral and compression samples, which play an important role in maintaining the bending characteristics of bamboo (Xuehua 2022).

Keywords: bending bamboo, bent shape keeping stability, density, MFA, MOE

Substituting bamboo for plastic to reduce plastic and carbon for green development

Fu Jinhe

International Bamboo and Rattan Organization, Beijing, China

Abstract: Waste plastic products are difficult to recycle and degrade. The increasing plastic pollution seriously threatens the survival of marine organisms. Micro-plastics enter the human body along the food chain, threatening human health. Finding plastic alternatives is an effective way to reduce plastic pollution.

Bamboo grows fast, matures in 3-5 years, and can be harvested sustainably. Bamboo shoots grow every year, and the yield is high. Once afforestation, it can be used sustainably. Bamboo is an important biomass material, and bamboo products can naturally biodegrade quickly after use. Substituting bamboo for plastic can also reduce carbon emissions, help achieve the dual-carbon goal, and achieve green development.

The International Bamboo and Rattan Organization takes the lead in the series of promotion activities of "Bamboo as a substitute for plastic", and launches "The Bamboo as a Substitute for Plastic Initiative" with the Chinese government to promote the formulation of favorable policies, technological innovation, market promotion and publicity.

Keywords: *plastic pollution, plastic reduction, carbon reduction, the bamboo as a substitute for plastic initiative, green development*

Effect of density enhancement on the water resistance of bamboo-fiber-reinforced composite

*Lei Wencheng, Zhang Yahui, Yu Wenji**

*Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing, China
chinayuwj@126.com*

Abstract: Bamboo has been paid much attention due to a variety of advantage in outdoor and construction field, such as the excellent mechanical performance. It is of great significance that improvement of water resistance is urgent for the application of outdoor or architecture except for keeping higher strength. Thus, bamboo fiber reinforced composite (BFRC) was developed, and widely used in many fields. In this study, the density enhancement on the water resistance of BFRC was evaluated with the density variation of 1.15 to 1.30 g/cm³ (including 1.15, 1.20, 1.25, 1.30 g/cm³). The density has a significant effect on the water absorption of the OBFRC, but has no significant effect on the width expansion rate and thickness expansion rate of the OBFRC. With the increase of density, the water resistance of OBFRC is notably improved. Further, the water absorption, width swelling rate and thickness swelling rate declined from 10.11% to 5.28%, 2.26% to 1.06%, and 9.00% to 7.67% respectively, which is determined by the reduction of porosity and the enhancement of bonding interface. Compared with other bamboo products, OBFRC not only retains better mechanical properties of natural bamboo, but also greatly enhances the water resistance of bamboo. As a bamboo-based composite with high strength and water resistance, it can be used in many fields, such as an advanced outdoor building material.

Keywords: *bamboo-fiber-reinforced composite, density, water resistance*

Study on the axial compressive performance of sprayed composite mortar-original bamboo composite columns and engineering application

B.B. Jin, J.P. Hao, L.M. Tian*

*Xi'an University of Architecture and Technology, Xi'an, China
jinbeibei517@163.com*

Abstract: A composite mortar was sprayed on the original bamboo skeleton, and after curing, the sprayed composite mortar-original bamboo structural system was formed, which integrated sound insulation, heat preservation, and fire resistance. The axial compression performance of 23 short columns and 7 slender columns were investigated, and several methods for calculating the strength and stability capacities of the original and sprayed composite mortar-original bamboo composite columns were proposed. Finally, the construction process of the actual project of the structural system was shown. The results showed that the axial compressive stiffness, ultimate bearing capacity and ductility of the composite short columns with loading of full section and local section were different, which was related to the section shape. Based on the verified finite element model, the influence law of the slenderness ratio, spraying thickness and initial deflection of bamboo on the axial compression performance of the composite column was explored. Finally, the formula for calculating the compressive bearing capacity of short columns was deduced. In addition, considering the effects of the variable cross-section and initial deflection of bamboo on stability, a calculation method for the buckling coefficient of slender column based on the edge fiber yield was proposed, and the results of the method were reliable.

Keywords: *sprayed composite mortar, composite column, axial compression performance, compressive capacity, stability coefficient*

Construction technology of large-span round bamboo arched structure—case analysis of bamboo and rattan pavilion of International Horticultural Beijing Exposition

Na Su^{1}, Benhua Fei^{2*}, Changzhan Sha^{3, 4}, Changhua Fang², Wei Xu¹*

*¹Nanjing Forestry University, Nanjing, China
2216306097@qq.com (*Corresponding Author)*

*²International Centre for Bamboo and Rattan, Beijing, China
feibenhua@icbr.ac.cn (*Corresponding Author)*

³Tsinghua University, Beijing, China

⁴The Chinese University of Hong Kong, Hong Kong, China

Abstract: Round bamboo has the characteristics of high-strength and lightweight, easy to bend stereotypes, is often used in architectural structures, especially large-span arched structures, which have a curved aesthetic architectural form. Based on the case of the bamboo and rattan Pavilion at the International Horticultural Exposition 2019 Beijing China (Beijing Expo 2019),

this paper summarizes the classic large-span bamboo arch bridges and buildings at home and abroad, analyzes the force characteristics of arched buildings, and the material applicability of round bamboo for large-span arched buildings, from the aspects of raw material preparation, architectural design, node structure, structural stress dispersion, tie strengthening, assembly and building health monitoring through on-the-spot investigation and literature research. It is pointed out that the application of standard round bamboo can greatly prolong the service life of round bamboo arch structure. Besides, the prefabrication of components not only reduces the engineering difficulty, but also promotes the assembly process of bamboo building to a certain extent. In addition, the ingenious node structure and structural design, as well as the pull knot strengthening, greatly improve the safety of bamboo building. Furthermore, the later health monitoring and safety maintenance further ensure the safety of large-span circular bamboo arch building. This research has important academic reference value for the research of round bamboo standard material, the construction of arch long-span round bamboo building technology system and the promotion and application of round bamboo structure, and has important economic and social benefits.

Keywords: *round bamboo, arched large-span structure, bamboo and rattan pavilion, construction technology, green building materials*

Study on the change law of lignin aggregation state during bamboo fiber separation process

Mingpeng Li, Ge Wang, Haitao Cheng

*International Centre for Bamboo and Rattan, Beijing, China
lmp20121221@163.com*

Abstract: The preparation of high-strength and high-modulus bamboo fibers with controllable morphology is an important way for high value-added applications of bamboo in automotive, aviation, construction and other fields. Lignin-carbohydrate (LCC) seriously hinders the rapid and controllable dissociation of bamboo fibers. Therefore, in this study, taking the interface as the starting point, a bidirectional solvent system composed of formic acid and hydrogen peroxide was selected to treat the stalks of *Citrus serrata*. The dissolution reaction of lignin in peroxyformic acid and the subsequent shearing of water solvent were used to combine lignin with LCC. Selective depolymerization and dissolution achieve the purpose of interface failure and achieve controllable separation of bamboo fibers. Through multi-scale characterization methods and molecular dynamics simulations, the bond breaking, depolymerization and dissolution mechanisms of lignin and LCC were elucidated, and the microdomain distribution of key components, chemical bond evolution and hydrogen bonding effects on interface bonding were revealed, and lignin aggregation state was revealed. Changes in the separation process of bamboo fibers under the peroxyformic acid biphasic system. The purpose of this research is to make use of the characteristics of bamboo that is easy to split vertically and difficult to separate horizontally, and through mild treatment methods, to prepare high-strength and high-modulus bamboo fibers with controllable morphology, which is of great significance to the application and development of high value-added bamboo fiber composite materials.

Keywords: bamboo fibers, lignin-carbohydrate, lignin aggregates, hydrogen bond

A novel bamboo engineering material processed by flattening and densification

Yu Luan^{1,2}, Changhua Fang^{1,2*}, Yifan Ma^{1,2}, Litong Liu^{1,2}, Yuting Yang^{1,2}, Menghong Jiang^{1,2},
Benhua Fei^{1,2}

¹ Institute of New Bamboo and Rattan Based Biomaterials, International Centre for Bamboo and Rattan (ICBR), Beijing, China

² Key Laboratory of National Forestry and Grassland Administration / Beijing for Bamboo & Rattan Science and Technology, Beijing, China
cfang@icbr.ac.cn (*Corresponding author)

Abstract: With the advantages of wide distribution, excellent performance, and easy processability, bamboo has been considered an important engineering material with great economic and environmental value. However, bamboo strips characterized by the arc shape cannot be directly applied to the production of the bamboo laminated board (a greatly developed bamboo engineering product) and must be pre-planed on four sides, which reduces the utilization rate to 30%-40%. On the other hand, the mechanical properties of bamboo show a decreasing trend from the outer part to the inner part due to the heterogeneous tissue structure, which leads to a low average strength. In order to increase the utilization rate and improve the mechanical performance, this study explored an integrated treatment of flattening and densification to produce a novel bamboo engineering material. The arc-shaped bamboo strips with high moisture content (70%) were hydro-thermally compressed by a hot press at 170°C and 190°C for 20 minutes. After treatment, the bamboo strips were flattened to rectangles with a decreased thickness. And the mechanical properties of treated bamboo including tensile strength, modulus of elasticity, flexural strength, compression strength, and shear strength were several times of those of natural bamboo.

Keywords: bamboo strip, flattening and densification, hydro-thermal treatment, the utilization rate, mechanical properties

In situ effervescence reaction-assisted mechanochemical extraction of orientin from bamboo leaves

H.R. Gao, J. Wang, Y.Q. Liu

International Centre for Bamboo and Rattan, Beijing, China
Wangjin@icbr.ac.cn

Abstract: Bamboo leaves are rich in flavonoids, which have a variety of biological activities, such as antioxidant, anti-aging, and antibacterial. Orientin is an important flavone C-glycosid

in bamboo leaves. At present, organic solvents (ethanol or methanol) are commonly used to extract flavonoids from bamboo leaves, but there are problems such as large amount of solvent and environmental pollution. In this study, a simple, green and fast method was developed for extraction and detection of orientin from leaves of bamboo (*Phyllostachys aureosulcata*) based on mechanochemical extraction. Citric acid and sodium bicarbonate were selected as reaction reagents. Water was used as extraction reagent and the detection was carried out based on HPLC diode array. The process parameters including citric acid/sodium bicarbonate ratio, extraction time and liquid/material ratio were selected to optimized. The results showed that the optimized extraction process of orientin from bamboo leaves was as follows: citric acid: sodium bicarbonate (1:2, mg/mg); material-to-liquid ratio 1:40 (g:mL); extraction time 20 min. Under this condition the extraction yield of orientin reached 0.6 mg/g, with the extraction time was shortened by 30%, and the organic solvent consumption was effectively reduced. This study provides a new green extraction strategy for orientin in bamboo leaves.

Keywords: bamboo leaves, mechanochemical extraction, orientin

Study on mechanical performance and construction technology of the rectangular steel tube frame-bamboo grid shear wall structure

Yang Yan¹, Chen Zhihua¹, Yan Xiangyu^{1,2*}, Zhang Mofan¹

¹ Tianjin University, Tianjin, China

xy_yan2005@163.com (*Corresponding Author)

² Tianjin University Research Institute of Architectural Design and Urban Planning Co., Ltd, Tianjin, China

Abstract: As a kind of low carbon material with fast growth cycle, bamboo has been paid more and more attention in the engineering field. In order to solve the problems of high pollution in construction, poor seismic performance of rural buildings, backward construction and transportation conditions in rural area, this paper proposed a rectangular steel tube frame-bamboo grid shear wall (SF-BGSW) structure suitable for rural houses and put forward the corresponding construction technology. The proposed SF-BGSW structure composed of rectangular steel tube boundary frame and inner grid shear walls arranged in two diagonal directions while all connections in this structure were connected by tapping screws, which could be completed at low cost and without large mechanical equipment.

In this paper, the static and dynamic performance of a one-story rectangular steel tube frame-hybrid grid shear wall structure was field tested, which was consisted of rectangular steel tube frame, bamboo grid shear wall (BGSW), timber grid shear wall (TGSW) and steel grid shear wall (SGSW). The results showed that the BGSW could improve the lateral-resistance ability effectively compared with pure steel frame while the lateral-resistance performance of the BGSW was weaker than that of the SGSW. Moreover, the lateral-resistance and natural vibration period of the BGSW were both similar with the TGSW. In general, the BGSW made of raw bamboo had good lateral resistance, which could replace the wood to a certain extent, and had a favorable application prospect especially in rural buildings.

Keywords: bamboo shear wall, rural building, low cost, lateral resistance, seismic performance

Flexural creep behaviors of bamboo subjected to different gradient variation directions and relative humidity

Xinxin Ma

*International Centre for Bamboo and Rattan, Beijing, China
maxx@icbr.ac.cn (Corresponding Author)*

Abstract: As more and more bamboo materials have been used for buildings, the bamboo creep property deserves more explorations because it is important to structural design and plays a critical role in serviceability of structure. In this study, the creep mechanism of bamboo over a wide range of scales from microstructure and bending flexural property to creep behavior were investigated. Firstly, the gradient functions of different vascular bundle distribution directions were obtained. The average value of gradient index n was respectively 2.16 and 0.29 when x axis ranged from different directions. Secondly, the flexural property test under different loading directions were analyzed. There were two groups, one group (O_T) was the fiber-rich outer culm wall in tension side, the other group (O_C) was the fiber-rich outer culm wall in compression side. It was concluded that Group O_T showed larger MOR and smaller MOE than Group O_C . In addition, the total energy consumed of Group O_T was larger than Group O_C , while the elastic energy was smaller. Thirdly, the creep property under different loading directions and humidity were examined, which is unique because no research about the bamboo creep performance under different humidity conditions has been completed according to the literature review. The creep deflection of Group O_T was larger than Group O_C whatever constant humidity or variable humidity was used. The relative creep of Group O_T was smaller than Group O_C under high humidity (90% RH) and variable humidity (30% RH-90% RH-30% RH), while larger under low humidity (30% RH).

Keywords: bamboo, creep, viscoelasticity

Reinforcement of epoxy with alkali-treated twisting bamboo fibers: wettability, mechanism, and fractal theory

Shaohua Gu¹, Jihe Chen¹, Wenfu Zhang^{1,2}, Wenting Li¹, Smith Li³, Haitao Cheng¹, Ge Wang¹, Cuicui Wang^{1}*

¹ *International Centre for Bamboo and Rattan, Beijing, China
amicheal@google.com (*Corresponding Author)*

² *Zhejiang Forestry Academy, Hangzhou, China*

³ *University of North Texas, Denton, USA*

Abstract: Epoxy composites were prepared from neat and alkali-treated twisted bamboo fibers (TBF). Alkali treatment leads to an increase in composite tensile strength (TS). Maximum TS is achieved at around 3 wt% NaOH content, which was 242.40 MPa, 146.79% higher than untreated TBF reinforced epoxy resin (TBF/EP) composites. The improved performance is due to improved inherent bamboo fiber properties and wettability. Dynamic contact angle showed that alkali treatment decreases TBF and bamboo fiber (BF) surface energy and polarity components. Compared with BF, the twisted structure of TBF can reduce the total surface energy (6-10mN/m), and the change was more stable. This is conducive to improving wettability and reducing pores, resulting in an increased interfacial adhesion, improvement of stress transfer. In-situ electron microscopy showed that the main local deformation processes associated with TBF were its fiber fracture and interfiber slip, while TBF/EP composites were fractured and debonded; the shear yielding of the matrix accompanies the latter. The increased inherent strength of the fibers and interface results in an increase in the fracture initiation stress and fracture energy of the TBF/EP composites independent of the twist structure of TBF. These results were supported by fractal dimension analysis regarding proper alkali-treated and interfacial adhesion between the TBF and epoxy matrix. The 3 wt% alkali-treated TBF/EP composites fractal dimension D reached a maximum value of 2.1756, similar to the TS results. There was a linear correlation between lg (TS) and fractal dimension D, indicating that the fractal dimension is feasible for TBF/EP composites.

Keywords: *twisting bamboo fiber, interface, wettability, preparation technology*

Supplement of bamboo extract lowers serum monocyte chemoattractant protein-1 concentration in mice fed a diet containing a high level of saturated fat

*Jason K. Higa, Wanyu Liu, Marla J. Berry, Jun Panee**

Department of Cell and Molecular Biology, John A. Burns School of Medicine, University of Hawaii at Manoa, Honolulu, USA

Abstract: Monocyte chemoattractant protein-1 (MCP-1) is an inflammatory chemokine p-regulated in obese subjects, contributing to the development of type 2 diabetes. The present study investigated the inhibitory effect of an ethanol–water extract from bamboo (BEX, *Phyllostachys edulis*) on the blood concentration of MCP-1. 57BL/6J mice were fed a standard diet or a high-fat diet with or without the BEX supplement (11 g dry mass/17 000 kJ) for 6 months. A total of ten mice were used in each group. Body weight and food consumption were measured weekly. After euthanasia, the weight of visceral fat and circulating MCP-1 concentration were measured. In comparison with the standard control group, the high-fat control group had increased body weight, abdominal fat storage and serum MCP-1 concentration by 60 % (P,0.001), 266 % (P,0.001) and 180 % (P,0.01), respectively. In comparison with the high-fat control group, the high-fat BEX group showed a 3 % decrease in body weight (P,0.01), 24 % decrease in mesenteric fat depot (P,0.01) and 49 % decrease in serum MCP-1 concentration (P,0.05). The present study suggests that the BEX supplement in the high-fat diet ameliorates elevated MCP-1 concentrations in the blood, and whether this is

related to modulated endocrine properties of the visceral fat is to be studied.

Keywords: *monocyte chemoattractant protein-1, high-fat diet, bamboo extract, mesenteric fat*

Production and characterization of long bamboo fibre composites for high performance applications

L. Osorio, A. Gómez-Alzate, L.A. Toro-Carvajal, F.N. Jiménez-García, E. Trujillo

Universidad Autónoma de Manizales, Manizales, Colombia

Abstract: The current research project aims to develop high quality long bamboo fibre composites for structural applications. Optimal results have been achieved thanks to the characteristics of this natural fibre, such as high strength and stiffness, low density and an extraordinary and complex microstructure.

Along this research, individual technical bamboo fibres and unidirectional bamboo fibres/epoxy composites from the species *Guadua angustifolia*, have been prepared and their microstructure and mechanical properties were characterized. Technical fibres are extracted using a purely mechanical process that preserves the integrity of the fibre structure, as well as the mechanical properties with a Young's Modulus of 43 GPa and tensile strength of 800 MPa. Also, bamboo fibre composites were characterized with optimal results for both tensile and bending properties, the measured modulus for the composite reaches 95% of the theoretical value.

In addition, to predict and optimize the mechanical performance of bamboo fibre composites under different loading conditions, a model using Finite Elements is currently under development. First results have shown good agreement with composites' experimental bending properties, indicating that modelling tools may be used to simulate and design bamboo fibre composite materials in different applications.

Finally, as a first structural application, and considering the different structural, physical and technical characteristics of bamboo fibres, a dynamic prosthetic foot is under development using long fibres combined with a thermoset matrix. This first application represents the first step towards the real use of long bamboo fibres in high performance composite materials with a sustainable and renewable alternative.

Keywords: *Bamboo fibres, bamboo fibre composites, mechanical properties, simulation*

Parametric designed joints for bamboo spatial structures as a strategy for incrementing bamboo architecture in Brazil.

Brianna Catharina Bussinger, Claudia Terezinha de Andrade Oliveira*

University of São Paulo, São Paulo, Brazil

Abstract: Bamboos' morphology is naturally suitable for construction purposes - it is cylindrical, hollow, tapered and has intermediate nodes (Janssen, 2000). However, its organic nature and diverse dimensions become a major obstacle while designing joints. The use of bamboo as a construction material in the Brazilian context remains limited due to a lack of qualified labour and cultural approach in building methodology. Since there are no available traditional jointing techniques to draw from, it is one of the main barriers to be addressed so that its architectural use can be increased. Digitally designed and fabricated joints in bamboo structures combine high and low technology to address problems in standardisation. By redesigning and prototyping joints from an existing building, it is possible to establish a comparison between hand-made and digital joints. Joints from the Amana Key building by Leiko Hama Motomura were chosen as a reference to reverse engineer into parametric designed ones following these steps: (1) Redesign existing joints using parametric software; (2) Input new joints into a 3D structural model; (3) Set up parameters in definition to adapt to spatial truss (4) Digitally fabricate one-of-a-kind joints (5) Assembly. Expected advantages to be identified include: joints transferring force through friction on the inner surface or compression to the diaphragm (Widyowijatnoko, 2012) can be perfectly fitted and mainly, technology can be used as a tool to fill in the specialised labour gap while possibly creating a new trend in bamboo architecture.

Keywords: *Brazilian bamboo architecture, parametric design, joints, bamboo spatial truss, digital fabrication*

The effect of bamboo extract on hepatic biotransforming enzymes – findings from an obese–diabetic mouse model

Cheryl L.K. Koide, Abby C. Collier, Marla J. Berry, Jun Panee

Abstract: Bamboo leaves are used as a component in traditional Chinese medicine for the antiinflammatory function. Our previous studies have demonstrated that an ethanol/water extract from *Phyllostachys edulis* ameliorated obesity-associated chronic systemic inflammation in mice, and therefore relieving the symptoms of type 2 diabetes. The aim of this project was to further investigate the effects of this bamboo extract on hepatic biotransformation enzymes in both lean and obese mice, as an initial step in the toxicological evaluation of using this traditional medicine in obese/diabetic population. Materials and methods: Male C57BL/6J mice were randomized to 4 groups and fed standard (10% kcal from fat) diet with or without bamboo extract supplementation at a dose of 10 gram per kilogram diet (n = 10 and n = 9, respectively), or high fat (45% kcal from fat) diet with or without bamboo extract (n = 8 and N = 7, respectively). The dietary treatment lasted for 6 months. Subsequently, the activities and expression of the major Phase I and II hepatic biotransformation enzymes were assessed in subcellular fractions from murine livers. Results: Three groups of mice, lean bamboo extract-supplemented, obese/diabetic, and bamboo extract-supplemented obese/diabetic, showed greater activities of cytochromes P450 1a2 and 3a11 compared to control but no changes in the expression level of these proteins. For Phase II enzymes, bamboo

extract supplementation in lean mice caused decreased glutathione-S-transferase activity (-12%) and greater uridine diphosphate glucuronosyltransferase activity (+46%), but had no effect on sulfotransferase activity. Conversely, the obese/diabetic condition itself increased glutathione-S-transferase and uridine diphosphate glucuronosyltransferase activities, but decreased total sulfotransferase activity and sulfotransferase 2a1 expression. Conclusions: Bamboo extract and obesity/diabetes show significant independent effects on hepatic biotransformation as well as interaction effects in mice. These changes may alter the clearance of endoand xenobiotics, including bamboo extract itself, hence this effect should be carefully considered in the medicinal application of bamboo extract as it has potential to alter its own metabolism and that of other medications concurrently administered to obese diabetic patients.

Keywords: *bamboo extract, obesity, diabetes, phase I enzyme, phase II enzyme, liver*

The role of bamboo pith ring in gluing interface

*Lin Chen^{1,2}, Jing Yuan^{1,2}, Xianke Wang^{1,2}, Bin Huang^{1,2}, Xinxin Ma^{1,2},
Changhua Fang^{1,2}, Xiubiao Zhang^{1,2}, Fengbo Sun^{1,2}, Benhua Fei^{1,2*}*

¹ *Department of Biomaterials, International Centre for Bamboo and Rattan, Beijing, China*

² *Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China
feibenhua@icbr.ac.cn (*Corresponding Author)*

Abstract: Bamboo pith ring (BPR) was removed to ensure the gluing quality in the traditional production of bamboo composites, leading to material waste and increased energy consumption. In this study, fine surface sanding was carried out to treat the bamboo surface. The wax layer and pith film that affected the bonding in bamboo skin (BS) and BPR were removed, and the bamboo could form an excellent adhesive force. The fine gluing process model was constructed based on the single factor and response surface model. The maximum shear strength of the adhesive layer was 11.08 MPa obtained by and at temperature, time, and pressure of 143°C, 25 min, and 1.75 MPa from the response surface model, respectively. In gluing process, PF resin can permeate the stone cell in BPR, forming a mechanical interlocking and interpenetrating network system, and reacts with cellulose, hemicellulose, and lignin of stone cell walls forming chemical force. The cells in BPR and bamboo middle (BM) are vertically staggered, forming vertical interlacing layers at the bonding interface in Bamboo composite. BPR retention in the composites can reduce the deformation rate of bamboo block and bamboo composites in the longitudinal, radial, and tangential directions during wet expansion and dry shrinkage.

Keywords: *bamboo composite, bamboo pith ring, bonding interface, bonding mechanism*

Experimental investigation of dynamic properties of timber-concrete composite beams

Wen Bo^{1,2*}, Yang Hui Feng¹, Shi Ben kai¹

¹ College of Civil Engineering, Nanjing Tech University, Nanjing, China
442789709@qq.com (*Corresponding Author)

² College of Architecture, Sanjiang University, Nanjing, China

Abstract: Due to the relative light mass and low stiffness of timber, it is prone to large vibrations when used in floor, affecting floor's comfort and even safety. The first part of this report provides an overview of the vibration-related research on modern timber floors, covering timber joist floors, CLT and TCC floors; research methods include laboratory tests, in-situ test, subjective evaluation and finite element analysis, etc. The research contents mainly include static load deflection, natural vibration frequency, damping, excitation response speed and acceleration, etc. Vibration control develops from qualitative control to quantitative control, from static load (state) to dynamic load (state) and combination of dynamic and static load (state), from single index to multi-index comprehensive control.

Due to the lack of research on the vibration performance of timber-concrete composite floors, the current design still lacks an effective basis. As an important part of the TCC floor, the timber-concrete composite beam is a breakthrough point for opening related research. The second part mainly reports the dynamic test research of several new timber-concrete composite beams including using of steel bar truss slab, lightweight aggregate concrete, crossed inclined coach screws connections, planted steel plate connections and other different construction practices. In this investigation, the dynamic properties of the composite beams are tested and numerically explored, and their dynamic properties such as natural vibration frequency and damping ratio are analyzed, and the influence of parameters such as interface connection type and the dimensions on the dynamic performance of the composite beam is discussed.

Keywords: timber floor, vibration performance, control index, timber-concrete composite beam, dynamic properties

In situ synthesis of mesoporous carbon-encapsulated Iron nanoparticles derived from rattan for efficient adsorption

L. Shang, X. Liu, S. Yang, G. Tian, Z. Jiang*

Key Laboratory of National Forestry and Grassland Administration/Beijing for Bamboo and Rattan Science and Technology, Beijing, China
jiangzh@icbr.ac.cn(*Corresponding author)

Abstract: Carbon-encapsulated metal nanoparticles (CEMNPs) have been shown to be feasible sorbent due to its advantages of being environmental friendly and recyclable. Biomass material is an excellent raw material for the preparation of CEMNPs. But the preparation process is relatively complex. Rattan has abundant pore structure and straight stem, and the

inherently open pores of the rattan structures are more beneficial to the metal solution infiltration, which make the two-step thermal pyrolysis simplified into one-step. Thereby, we herein attempted to develop CEMNPs for the adsorbent using rattan as the carbon source and ferric nitrate as iron source, and the effects of different iron content and temperature were investigated. Also, the nanoparticles were characterized for physicochemical properties by SEM, TEM, XRD, Raman, and FTIR methods. The morphologic results showed that, when the iron content was 10% and the temperature was 1000°C, the nanoparticles had more homogenous particle sizes ranging mainly from 50 to 60 nm, and the core-shell structures with α -Fe in situ encapsulated within 10-30-layer graphitic shell. The N₂ adsorption results showed their specific surface area was 135.29 m²g⁻¹ with 3.07 nm average pore size. The adsorption performance results exhibited that CEINPs were effective to adsorb Methylene blue. The adsorption capacity went up the increase of the iron contents from 5 to 15%. The maximum value was 186.22 mg g⁻¹ at 10wt.% iron content. The synthesized CEINPs derived from rattan would open a new path to develop dyes removal product for wastewater treatment.

Keywords: rattan, carbon-encapsulated iron nanoparticles, methylene blue, adsorption

Effect of hot-pressing temperature on water resistance of bamboo scrimber from macro to micro

*Wang Xiaoxia, Yu Wenji**

*Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing, China
chinayuwj@126.com*

Abstract: Bamboo scrimber is widely used in outdoor, and has potential for application in architectural structures. Water resistance has played an important role in application scenarios and lifecycle of bamboo scrimber. Thus, the effect of hot-pressing temperature on water resistance was investigated in this study. Moreover, the response of cells and interfaces of bamboo scrimber to various temperature was evaluated from the macro and micro level. It is performed that water resistance of the bamboo scrimber was significantly improved as the hot-pressing temperature increased from 140°C to 170°C. Further, the thickness swelling rate (TS) and the width swelling rate (WS) was significantly decreased by 59.3% and 75.4% under the 28h cycle test, respectively. The increase of hot-pressing temperature has negative correlation with the cracks in the transverse section and the deformation of specimen decreases, which performed significant effect on improvement of dimensional stability. It is revealed that influence mechanism of temperature on water resistance could give a theoretical support for the optimization of bamboo scrimber, and provide reference for the quality evaluation. Consequently, the multi-dimensional study on the relationship between bamboo scrimber and impact factors such as temperature and moisture are conducive to demand of special technique of bamboo scrimber for different application scenarios. The results were also contributable to effective utilization in the perspective of energy consumption, material cost and performance, and improving the competitiveness of bamboo scrimber industry.

Keywords: bamboo scrimber, hot-pressing temperature, water resistance

Robust parameter identification for ductile timber connection

J. Liu^{1}, H. Yang²*

¹ Southeast University, Nanjing, China
945290530@qq.com (*Corresponding Author)

² Nanjing Tech University, Nanjing, China

Abstract: Moment-resistant timber frame with ductile timber connection due to its high lateral resistance, carbon emission reduction capacity and the application potential in high-rise structures has attracted extensive attention. In this study, a ductile timber connection with steel bracket was proposed. The proposed connection was experimentally studied and numerically analyzed. The model parameter of the connection was identified by an unscented Kalman filter (UKF). To prevent the interruption of the program and improve the stability of the program, the Cholesky decomposition in the UKF was superseded by singular value decomposition (SVD). To solve the problem of parameter determination of noise matrix, an adaptive noise estimator is embedded in the UKF program. Moreover, an assessment method was proposed to evaluate the accuracy of the numerical results. The experimental results show that the joint ductility can be increased to 7.11. The numerical result shows a good agreement with the experimental results. The stability of the parameter identification method is improved, and the model error of most node performance parameters is reduced to less than 10%. This parameter identification procedure could be extended to other connections with complex and unstable mechanical properties.

Keywords: parameter identification, Kalman filter, singular value decomposition, ductile timber connection, steel bracket

Evaluation of Tre Gai (*Bambusa blumeana*) bending strength perpendicular to the fibers along culm height

D. P. Hindman^{1}, E. Satir¹, A. D. Rara², R. Okutan¹, C. T. Dean¹, K. Strong³,
J. Pomponi⁴, J. Hauptman¹*

¹ Virginia Tech, Blacksburg, VA, USA
dhindman@vt.edu (*Corresponding Author)

² Boise Cascade, Stephens City, VA, USA

³ Arclin, Springfield, Oregon, USA

⁴ Benelli USA, Arlington, Virginia, USA

Abstract: An identified need for the growth in structural use of bamboo is a more definite understanding of mechanical properties and the use of efficient test methods. A current focus

of research has been the development of lightly modified bamboo panels, creating cross-laminated bamboo composite panels with a minimum of machining to create adhesive bond surfaces while retaining the inherent circular shape and cross-section of the original culm. As part of the study of lightly modified bamboo, questions were raised about the role of perpendicular-to-fiber loading on the culms and the effect of node position and position along the length of the culm. The purpose of this paper was to measure the bending strength and stiffness perpendicular to the fibers for both node and internode sections along the entire length of commercially purchased Tre Gai (*Bambusa blumeana*) culms. Eight culms were sectioned over a 4 meter length. A novel digital scanning method was employed to compute the inner and outer diameter of each section. Node strength was approximately 2.9 times greater than the internode strength. While variation in the strength and stiffness were observed over the length of the culm, no established trend was found. Correlations between the culm thickness and strength values were found. The use of the digital scanning tools was found to greatly aid the measurement of the bamboo culm diameter and thickness.

Keywords: *Bambusa blumeana*, bending perpendicular to fiber, digital imaging, mechanical properties

The inhibitory effect of bamboo extract on the development of 7,12-Dimethylbenz[a]anthracene (DMBA)-induced breast cancer

Yanling Lin, Abby C. Collier, Wanyu Liu, Marla J. Berry, Jun Panee

Abstract: The incidence of breast cancer among women is high and increasing. This study investigated the inhibitory effect of an extract from bamboo *Phyllostachys edulis* on the development of 7,12-dimethylbenz[a]anthracene (DMBA)-induced breast cancer in female Sprague-Dawley rats. The rats were fed with bamboo extract (BEX) supplemented diet or control diet, and treated with DMBA after 3 weeks of the dietary regime. The incidence of mammary tumors was monitored by palpation for the next 11 weeks. At the end of the experiment, blood samples were collected for total antioxidant capacities (TAC) assay and liver samples for phase II enzyme activity assays. The TAC values, total contents of phenolics and flavonoids of BEX were also measured. The results showed that BEX delayed the onset of mammary tumor by 1 week, decreased the tumor incidence by 44% and tumor multiplicity by 67%, and increased the total sulfotransferases (SULT) activity by 63%. BEX showed high levels of TAC, total phenolic and total flavonoids. However, the serum TAC values were not affected by BEX supplementation. In summary, the results indicate that BEX possesses a potent anti-breast cancer effect, and the upregulation of SULT activity, therefore estrogen metabolism may be the underlying mechanism.

Keywords: *breast cancer*, 7,12-dimethylbenz[a]anthracene (DMBA), bamboo extract (BEX), total antioxidant capacity (TAC), flavonoids

The effects on mechanical properties of bamboo treated with fire

S. Greco^{1*}, L. Molari¹, L. Mentrasti², M. Fabiani³

¹ Alma Mater Studiorum – Università di Bologna, Bologna, Italy
s.greco@unibo.it (*Corresponding Author)

² Università Politecnica delle Marche, Ancona, Italy

³ Independent Researcher, Secondary school teacher, Pesaro, Italy

Abstract: Bamboo shows good mechanical properties, but it is very susceptible to environmental conditions. There are many processes which tries to improve the durability against biotic and abiotic factors. Generally, the bamboo treatments are classified as chemical and non-chemical. The first are very efficient, but they could be expensive and unsafe for human health and environment. The latter are efficient, they could be lightly cheaper, and they represent a good solution in terms of sustainability. Among non-chemical treatments, the heat processes have attracted increasing attention because they improve the durability of bamboo. However, this kind of treatments could a notable impact on mechanical properties.

The study aims to show the effects of fire treatment on mechanical properties of bamboo. In particular, the effect of traditional fire treatment on *Phyllostachys viridis* growth in Italy is investigated. The value of moisture content, density, tensile, compressive, bending strength of treated and untreated bamboo are obtained according to ISO 22157 and UNI 11842.

The results show a low influence of the treatment on the mechanical performance of bamboo.

Keywords: bamboo durability, fire treatment, mechanical characterization of bamboo, Italian bamboo

Low-cost mussel inspired surface modification of bamboo fibers by poly (catechol/polyamine) coating and its use as a reinforcement of PLA matrix

Mustapha Boukhir^{1,2,3*}, Wanzhao Wang^{1,2,3*}, Zhenghao Chen^{1,2,3},
Kaiqiang Zhang^{1,2,3}, Shuangbao Zhang^{1,2,3*}, Wei Song⁴

¹ MOE Key Laboratory of Wooden Material Science and Application, College of Materials Science and Technology, Beijing Forestry University, Beijing, China

² Beijing Key Laboratory of Wood Science and Engineering, College of Materials Science and Technology, Beijing Forestry University, Beijing, China

³ MOE Engineering Research Center of Forestry Biomass Materials and Bioenergy, College of Materials Science and Technology, Beijing Forestry University, Beijing, China

⁴ Department of Biomaterials, International Centre for Bamboo and Rattan, Beijing, China

shuangbaozhang@163.com (*Corresponding author)

† These authors have contributed equally to this work and share first authorship.

Abstract: As a new type of composite, bamboo fiber/Polylactic-acid composite has broad development prospects because it combines the advantages of both bamboo fiber and polylactic-acid. However, the poor interfacial compatibility between polar bamboo fiber (BF) and non-polar polylactic-acid (PLA) has always been the key problem affecting the properties of the composite. In this paper, an effective low-cost catechol/polyamines system has been used to replace expensive dopamine to modify the surface of bamboo fiber. The effects of different phenolic-amine modification processes and phenol-amine molar ratios on the surface characteristic of the modified bamboo fiber and the properties of bamboo plastic composites were explored. Results showed that under the modification process conditions of catechol/TEPA combination and molar ratio of 1:1, the composite has shown the best mechanical properties, in which the flexural strength and modulus, tensile strength and modulus and impact strength are increased by 18.8%, 20.9%, 16.8%, 10.9% and 18.6% respectively compared with the unmodified composite. In addition, it has also shown the best thermal properties. Moreover, the modification of catechol/polyamine didn't damage the crystal structure of cellulose and it has no obvious effect on the crystallization properties of the composites. This indicates that the surface modification had significantly improved the interfacial adhesion between the BF and the PLA matrix.

Catechol/polyamine modification strategy can reduce the modification cost (only 1% of dopamine cost), and has a shorter reaction time compared to dopamine. It is more suitable for large-scale production of high-performance composites.

Keywords: *bamboo fiber, polylactic acid, catechol, polyamine, interfacial compatibility*

Ecologically self-anchored FRP-bamboo composite anchor bolts: concepts and experiments

*Xiang Li, Dongpo Zhang, Xinmiao Meng**

*Department of Civil Engineering, Beijing Forestry University, Beijing, China
mengxinmiao@bjfu.edu.cn (*Corresponding author)*

Abstract: Building an ecological civilization is of fundamental importance for the sustainable development of the Chinese nation. With the rapid and large-scale construction of infrastructure in our country, the accompanying engineering slopes face the challenges such as poor stability, more secondary barren land, and serious soil erosion. The ecological slope is an important way to achieve lucid waters and lush mountains. Nonetheless, the anchor bolt used in the ecological slope only considers the slope safety but ignores the collaborative work with the root systems. In order to solve the above problems, this project proposes a novel self-anchored composite anchor bolt made of fiber reinforced polymer (FRP) and bamboo material. Such anchor bolt could provide enough load-carry capacity and durability, and could also attract the roots growing around the bolt through the degradation of bamboo and ecological grouting material. The composite bolt was mainly manufactured by winding and bonding fibre-based materials layer by layer. Through tensile and pull-out tests, its self-anchored structure was verified and optimised to give full play to the parallel-to-fibre tensile strength of materials. On the other hand, the grout used for anchoring bolts and cultivating plants was formulated

from magnesium oxide, phosphate, soil, water and other materials in a particular mix proportion. The physicochemical properties of the cement-based grout, which were highly controlled by the mix proportion, were assessed and improved based on the tests of porosity, compressive strength, pH value, etc. Furthermore, methods such as durability tests of the composite bolt under various load conditions and harsh environments and the growth monitoring of plant roots were employed to estimate the anchor system's long-term anchoring performance and ecological advantages for constructing ecological slopes.

Keywords: *FRP-bamboo composite structures, ecological slope, planting-growth characteristic, self-anchored bolt, pull-out test*

Bamboo gridshells through computational design and construction

E.A. Nurdiah^{1}, T. H. Wang², W. S. Chang^{1,2}*

¹ Petra Christian University, Surabaya, Indonesia

² The University of Sheffield, Sheffield, United Kingdom

*estian@petra.ac.id, eanurdiah1@sheffield.ac.uk (*Corresponding Author)*

Abstract: Using bamboo in a gridshell, which is considered an efficient structural system, can enhance material efficiency because they require fewer materials. However, it is challenging due to bamboo's character and properties, such as anatomy, physical and mechanical properties. Gridshell structure as designed is different from as built; the variation of material, the design and the construction process might affect the result. This paper aims to analyse the structural behaviour of bamboo gridshells through computational modelling and finite element analysis (FEA), and compare the test results on built models. The gridshell structures were modelled in Rhinoceros using plug-ins, Grasshopper and Kangaroo, to identify reachable height and potential curvature. After the models were completed, two full-scale gridshells made from bamboo culms and split were erected and tested using imposed loads, and the deformations were measured. The models were exported to commercial software, Abaqus, for FEA. We identified the stress distribution and nodal displacements. Results from FEA were validated by comparing the test data. During the construction process, it was found that the constructional constraint of bamboo was its curvature. Some members failed due to buckling and splitting. As a result, the maximum curvature of bamboo gridshell in construction was smaller than that from modelling. Meanwhile, the recorded displacement showed higher values than the results from FEA. It was concluded that the depth of curvature should be considered as the control variable when designing bamboo gridshells.

Keywords: *bamboo gridshell, computational modelling, finite element analysis, built model, depth of curvature.*

Modelling, design and optimization of connections for bio-based laminated structures

Da Shi¹, Cristoforo Demartino^{2*}, Zhi Li¹

¹Zhejiang University, Hangzhou, China
da.21@intl.zju.edu.cn; li_zhi@zju.edu.cn

²Zhejiang University / University of Illinois at Urbana Champaign Institute, Zhejiang University, Hangzhou, China
cristoforodemartino@intl.zju.edu.cn (*Corresponding Author)

Abstract: Through the lamination process, natural bamboo and timber can be processed into engineered structural materials which will have enhanced properties and not suffer from the irregularities of parent natural materials. Bio-based laminated composite materials made from timber and bamboo are now widely used in the construction sector. Their mechanical properties as much as their renewability, economic aspect, and potential carbon storage capacity offer promising ongoing and upcoming applications. This study focuses on the axial monotonic and hysteretic behavior of their single elements namely bolted steel to laminated timber and bamboo (glulam) connections and then a phenomenological uniaxial hysteretic model for single connections elements is developed with a Genetic Algorithm (GA) based parameter identification procedure. The validated model was then incorporated into a simplified model of full-scale bio-based laminated structures such as truss system and post and beam knee brace system to evaluate their seismic performance.

Keywords: laminated composite materials, hysteretic model, parameter identification, bolted connections

The biological function of *PheTB1a/b* gene in Moso bamboo (*Phyllostachys edulis*)

M.X. Shao, M.S. Zhou, J.Y. Chen, L. Liu, X.Q. Guo*

State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University, Hangzhou, China
xqguo@zafu.edu.cn (*Corresponding Author)

Abstract: Moso bamboo (*Phyllostachys edulis*) is an important economic bamboo species in China. The normal development of bamboo bud/shoot determines its yield. The *BRC1/TB1* gene plays an important role in the formation and development of axillary meristems and axillary buds. In this study, two *TB1* homologous genes, *PheTB1a* and *PheTB1b*, were obtained from moso bamboo by RT-PCR. Both proteins encoded by the two genes contain a conserved TCP domain which is composed of Basic, HelixI, Loop and HelixII motif. *PheTB1a* was highly expressed in the lateral buds and the least expressed in the young leaves, while *PheTB1b* was only expressed in the lateral buds. The expression patterns of *PheTB1a* and *PheTB1b* in shoots with different sizes showed the similar trend, displaying a gradual decrease during the

developmental process of lateral shoots. Both *PheTB1a* and *PheTB1b* proteins were localized in the nucleus. Y2H and BiFC showed that *PheTB1a* and *PheTB1b* interacted with TCP and GRA S. *PheTB1a*-OE and *PheTB1b*-OE Arabidopsis have multiple stems. Y1H and luciferase assay revealed that *PheTB1a/b* could bind to the *cis*-elements in the gene of *PheGT1*. This study provides a reference for further analysis of the biological functions of *PheTB1a/b*, and provides basic information for the molecular mechanism of bamboo bud/shoot development in moso bamboo.

Keywords: Moso bamboo, *BRC1/TB1* gene, bamboo shoot, TCP, GRAS

Thematic Area 4.

Working Together for Inclusive and Green Development





Bamboo as a nature-based solution to climate change mitigation: biomass, products, and carbon credit

C. Pan^{1,2}, J. Chen¹, A. Shrestha^{1,2}, J. L. Innes^{1,2}, G. Zhou², N. Li³, J. Li³, Y. He³, C. Sheng⁴, J. O. Niles⁵, G. Wang^{1,2}*

¹ *University of British Columbia, Vancouver, Canada
Guangyu.wang@ubc.ca (*Corresponding Author)*

² *Zhejiang A&F University, Lin'an, China*

³ *China Green Carbon Foundation, Beijing, China*

⁴ *Northeast Forestry University, Harbin, China*

⁵ *University of California, San Diego, USA*

Abstract: Global researchers, scholars, and decision-makers have attached great importance to combating climate change with nature-based solutions. Bamboo, a fast-growing woody grass widely distributed in the pan-tropical zones, continuously contributes to mitigating climate change. However, few researchers have comprehensively synthesised the role of bamboo in climate change mitigation from all aspects. We systematically reviewed 91 research articles under a thematic analysis; we derived a comprehensive knowledge-based framework for bamboo's contribution to climate change mitigation as a nature-based solution, from biomass carbon sinks, product carbon storage, and project carbon credits. Global bamboo forest ecosystems present high carbon sequestration and storage capacity, influenced by biotic and abiotic factors. Biotic conditions, including the leaf area index, culm density, and DBH, and abiotic factors, including climate disasters, management strategies, and microclimate, can influence carbon storage in biomass to different degrees. However, most studies focused on several specific species, such as Moso bamboo and Lei bamboo, and limited the scope in Asia. Additionally, the bamboo forest ecosystems can sustainably yield bamboo timber for manufacturing durable products, further storing a significant amount of carbon in the long term. Most studies demonstrated the net-negative carbon life cycle of bamboo-based products compared to conventional productions. Bamboo forests have considerable potential in carbon offset trading, significantly protecting natural resources and reducing poverty. With future available bamboo project methodologies, bamboo can be increasingly crucial in mitigating climate change. This review is essential to the greater goal of carbon neutrality and for decision-makers to formulate climate change policies more scientifically.

Keywords: *carbon storage, carbon sequestration, carbon trading, carbon offset, forest carbon*

Bamboo and rattan for ecosystem restoration: case study, Kenya

D. M. Karanja^{1,2}

¹ *University of Nairobi, Chiromo, Kenya: MSc. Climate Change*

² *Department of Water, Irrigation, Environment & Climate Change, County Government of Nyeri, Nyeri, Kenya*

Abstract: The sustainable use of rattan and bamboo is crucial with consideration to an array of Sustainable Development Goals, including poverty eradication, providing affordable energy and housing for all, addressing climate change, using natural resources, and protecting terrestrial ecosystems. The special characteristics of bamboo and rattan are appropriate for green development plans, by providing a fast-renewing replacement for timber fuel as well as cutting-edge building materials to substitute emissions-intensive materials such as steel, plastics, and concrete. Bamboo, technically a grass has a fibrous root system that can help bind soils to fight desertification, and its growth rate of up to a meter in a day offers powerful carbon sequestration opportunities.

As of 10 September 2020, bamboo is now recognized as the 16th cash crop in Kenya. In 2020, about 240 farmers and players were identified in the bamboo industry. The low uptake has been associated with the expensive cost of seedlings whereby a seedling goes for KES. 200-350 which is not pocket-friendly for an average smallholder farmer. Also, the limited variety of species in the country forces farmers who have ventured into the industry to import seeds from China at relatively high costs. In addition, knowledge of bamboo growing and management is restricted to a few areas in the country. There is, therefore, a need for the government to steer bamboo towards the private sector, introduce a bamboo curriculum in education centers and allocate subsidies for bamboo seeds and seedlings to promote affordability to smallholder farmers.

Keywords: *bamboo, sequestration, sustainable, knowledge, subsidies*

Study on high quality development of bamboo industry in Guizhou Plateau, China, based on industrial Chain theory

Zhang Xi^{1,2}, Zhang Tingjia¹

¹ *Guizhou Provincial Academy of Forestry, Guiyang, China*

² *Office of Guizhou Provincial Characteristic Forestry Industry, Guiyang, China
zhangxigzfa@tom.com*

Abstract: Guizhou Province is located in the eastern Yunnan-Guizhou Plateau, China, and the origin and distribution center of bamboo in the Asian-Pacific regions, with abundant bamboo forest resources. The provincial government listed the bamboo industry, which has become an important path to help poverty alleviation and rural revitalization, as one of twelve mountainous characteristic and efficient agricultural industries in 2019a.

Promotion methods based on industrial chain theory in 2019a had included: 1) Industrial development layout had been proposed for key belts of "two mountains and two waters", as well as key plots scattered throughout the province. On account of the layout, series maps had been drawn for industry chains development, products for application field and regional market, technology lines, work plans, etc. 2) Promotion modes had constantly been optimized for the mechanism of "1+2345" and the goal of "1+1111", and focused on "chain building, chain complement, chain extension, chain stability and chain strong" of the bamboo industry development. 3) Focusing on both ends of research and market of the bamboo industry smile

curve, innovation chains have been deployed around industrial chains. High-end enterprises and famous brands of the industrial chain have come to the province. 4) Centering on the construction of the industrial chain, supply chains, such as important infrastructures, key technologies, raw materials, intermediate components, etc, has been extended.

Achievements in the bamboo industry from 2019a to 2021a had included: 1) Bamboo forest had been planted 5.3×10^4 hm² and reformed 6.7×10^4 hm² with a total area of 34.7×10^4 hm². 2) The output value of the bamboo industry reached 1.3×10^{10} RMB(¥) at 2021a, doubled that of 2018a. 3) A sequence of national brands, such as National Bamboo Industry Demonstration Park, National Bamboo Seed Resources Collection Library, National Forestry Leading Enterprises, etc, had moved into the Province, and a series of standards and patents related to the bamboo industry had been issued. 4) Some new products of “Guizhou Bamboo” brands for bamboo paper, bamboo materials and bamboo shoots had gone abroad, and scenic spots of bamboo forest park, bamboo culture, etc, had added a large number of tourists inside and outside. 5) An industrial chain network with bamboo paper, bamboo material, bamboo shoots and bamboo culture and tourism as the main chain had been formed. The development of the bamboo industry had gradually changed from government driven to two-way guidance of government and market, and the construction of industrial parks as the main direction.

Main conclusion: The bamboo industry in Guizhou province based on the theory of industry chain theory had achieved high quality development, together with significant economic, ecological and social benefits.

Keywords: *bamboo industry, industrial chain theory, high-quality development, Guizhou plateau mountainous,*

Use creative economy to promote the high quality development of bamboo products and bamboo industry

Tiejun Wang

*Sino-European International Research Centre for Creative Economy, Beijing, China
3093089609@qq.com*

Abstract: At present, the bamboo products of bamboo township in China are basically homogenized food materials, furniture, handicrafts, etc. Therefore, it is a problem to improve the bamboo cultural content and high added value. An effective way to solve this problem is to use creative economy combined with local bamboo resources and culture to develop bamboo products. For example, the bamboo liquor, developed by creative economy methodology, is made by a innovated traditional winemaking techniques and true bamboo resources in the South Sichuan bamboo Sea, bamboo functions described in Compendium of Materia Medica and local folk stories. It has become a high value-added product to meet spiritual and material needs. Bamboo liquor production methodology has obtained the Patent Certificate of Invention from the State Intellectual Property Office of the People's Republic of China. After being produced and put on the market, it's popular with consumers and becomes a high value-added bamboo product meeting with the spiritual and material needs. The application of creative

economy can create more low-carbon and carbon reducing bamboo products form a green circular economy of bamboo industry chain, and promote the high-quality sustainable development of bamboo products and bamboo industry.

Keywords: *creative economy, bamboo industry, high-quality development*

Using native bamboos to catalyze the recovery of degraded land on Amazonian artisanal mining sites

L. Binfieldl^{1}, M. Stern²*

¹ *University of British Columbia, Vancouver, Canada
lucybinf@mail.ubc.ca (*Corresponding Author)*

² *EcoDecision, Ecuador*

Abstract: Artisanal mining in the Amazon leaves behind severely degraded terrestrial and aquatic landscapes. Bamboos grow very fast, both vertically and horizontally, and rapidly colonize open areas. Results from other countries have effectively demonstrated bamboo's potential for the recovery of degraded land using these unique properties. In our project, currently in the testing stages, we are using native bamboos in a nature-based intervention to kickstart natural ecological succession and landscape recovery. We aim to lower costs and increase the speed and effectiveness of soil and vegetative recovery on degraded mine sites, bringing native biodiversity back, regulating the watershed, and reducing soil erosion and runoff. We are modifying both modern and traditional propagation methods to produce a natural resource base for planting. We focus on *Guadua angustifolia*, a commercially useful species that occurs naturally near mining areas of the southern Ecuador Amazon, the location of our demonstration site. Micropropagation, a modern technique that involves cloning plants in a sterile laboratory environment, is already underway, supported by university partners. Additionally, motivated local university students are being trained in traditional methods to propagate *Guadua* using new shoots with roots (chusquines), rhizomes, and cuttings from basal branches to grow new plants in a nursery. This innovation will be tested comprehensively, comparing success rates, costs, and limitations of both methods. We expect that this pilot project will show that that native bamboos can have a significant cost-per-hectare and speed advantage over other strategies for regreening degraded mining sites, notably the use of native trees.

Keywords: *Guadua angustifolia, native bamboos, propagation in vitro, vegetative propagation, landscape recovery*

Bamboo- the ideal tool for restoration of degraded landscapes

Muralidharan E.M.

INBAR Task Force of Sustainable Bamboo Management

Abstract: The unique morphological and growth characteristics makes bamboo ideally suited for its use in restoration of degraded landscapes and climate change mitigation efforts. In keeping with the essence of the contemporary principles of landscape restoration, bamboo planting does not merely re-establish the vegetation cover quickly but also engages the local community and contributes to economy by generating livelihood opportunities.

Bamboo, with its great diversity of species and forms, adapts well to a wide range of soils and climatic conditions. The phenomenally fast growth rates, extensive underground rhizome network and dense fibrous root system contribute to the ability of bamboo to quickly restore degraded soils, control soil erosion, conserve water and add organic matter to soil. The high carbon sequestration ability of bamboo and its conversion into durable products constitute a great potential for climate change mitigation and benefits accruing from carbon credits. The multiple uses of bamboo include the traditional uses in building, furniture, implements and as fuel, food and fodder and an expanding range of modern industrial uses. In recent times, bamboo is finding increasing use as engineered bamboo products and for bioenergy and paper/pulp industry. More evidence has been generated in recent times that demonstrate that bamboo is indeed ideally suited for restoring degraded forest and agricultural landscapes through improving the fertility of soils, enhancing biodiversity and becoming a driver of economic development besides contributing to fulfilling several of the SDGs. Examples of successful use of bamboo for landscape restoration from around the world is discussed.

Keywords: *landscape restoration, carbon sequestration, multiple uses, soil fertility, water conservation*

Brazil begins a new cycle of bamboo development

G.F. Katiane¹, S.A.L. Nery²

¹ *Brazilian Innovation And Sustainability Center, Londrina, Paraná. Brazil
presidencia@cebis.org.br*

² *Bamboo Parliamentary Front, Brasília, Federal District, Brazil*

Abstract: In 2011, the law on the National Bamboo Policy was passed. However, there were few advances in the production and value chain and in the domestic market, due to leaders with dubious conduct.

In order to enjoy advantage of the opportunities that bamboo represents to the country, in the context of food, civil construction, input for the paper, textile, wood industry, environmental services such as the recovery of degraded areas and carbon credit, and a source of renewable energy was created the Bamboo Parliamentary Front in 2020. Chaired by deputy Giovani Cherini, the front has the support of 215 deputies and 15 senators.

Given the continental dimension of Brazil, a forum with authorities is needed to build structuring, effective and synergistic public policies. The highlight is the use of bamboo as biomass for ethanol production in Mato Grosso. The biomass is a blend of 60% eucalyptus and

40% bamboo. Eleven contracts were formalized, with a term of 15 years, totaling 4,000 hectares. In August 2022, the state law to encourage bamboo was enacted in Paraná, with the objective of professionalizing the chair in order to renew the energy matrix to serve cooperatives, as well as the development of the wood and pulp industry. Recently, the project Capacity and potential for carbon sequestration in bamboo plantations and control mechanisms related to the Cooperation Agreements - National Foundation of Natural Sciences of China / NSFC and FAPESP was enabled.

Keywords: *parliament, governance, marketplace, cebis, management*

Bamboo green gold perspective

Maharaj Muthoo

Roman Forum, Rome, Italy

Abstract: Bamboo provides multi-purpose products for villages and towns, artisan and craft activities, resilient housing, flooring, furniture, fabric, fibre, food and fuel. Bamboos yield fast-growing versatile materials for high-tech industrial processing and commodities worth billions of dollars. Green growth policy paradigms are pertinent to bamboos for equitable economic growth, green jobs, business and industry.

Bamboos provide greenery in rural and urban landscapes while contributing to nutrient recycling, restoration of wastelands, soil stabilization and water phytoremediation. The importance of linking financing, innovative science and adaptive technology calls for convergent cooperation -locally, nationally and internationally.

It is timely to deploy national and international policy systems about economic, environmental, cultural and social dimensions of bamboo composites, their valorisation and quality assurance, benefiting custodians, producers, processors, entrepreneurs, consumers and concerned communities. More so with the emerging Payment of Ecosystems Services, Climate Change mitigation and adaptation, REDD+ remuneration, Green Climate Fund, carbon credits, and contribution to post-2015 Sustainable Development Goals (SDGs).

SDGs and Green Economy agenda for the ‘The Future We Want’ should raise recognition of bamboo as Green Gold for local livelihoods and overall economy. Efforts should be redoubled for placing productive propagation on firm footing of legality and sustainability. Being environmentally friendly, biodegradable, energy-efficient and versatile, enhanced bamboo products will assure their green credentials for globalization, ethical trade and market mechanisms. Policy level leadership and stakeholder stewardship should therefore motivate multi-functional bamboo resource management for holistic human welfare and green economy.

Keywords: *local, national and international benefits, global green economy*

Understand bamboo sectoral cluster models to support regional sustainable investment-finance (Yangtze River Delta and other examples)

Xiaoying Liu^{1,2}, Luc Boeraeve^{3,4}*

¹ *Natureherit DC, Shanghai, China*

² *Sino-EU Panel on Land & Soil (SEPLS), Rotterdam, The Netherlands*

*xyliu@natureherit.com (*Corresponding author)*

³ *American Bamboo Society (ABS), California, USA*

⁴ *Belgium Bamboo Society (BBS), Poperinge, Belgium*

Abstract: Despite fast growth and close to 1700 identified species widely distributed in tropical, subtropical and temperate climate zones in ca. 80 countries, bamboo only covers 0.8% (35 million ha) of global forest coverage (Note 1). This indicative figure shows the potential to shift timber product consumption that causes deforestation and worsening climate change, to bamboo-based products as greener substitutes.

To implement the shift timely and sustainably, numerous practices show that, bamboo resources managed in agro-forestry plantations, eco protection and restoration of degraded land, that can provide multiple raw materials for bamboo sectors besides improving the environment. Depending on bamboo species, local skills and technical levels etc., bamboo sectors should grow gradually in diverse combination of sectoral clusters and market value chains. The implanted local sectoral clusters set up a foundation for sustainable growth of green-circular economies.

This practical research over Bamboo Sectoral Cluster Models (BSCM) opens a new way for regional multi-actors to understand how suitable bamboo sectors and spatial development plans could support regional sustainable investment-finance, that include policy makers, entrepreneurs, farmers, consumers, developers, investors and financiers etc. The Yangtze River Delta (YRD), key example of an advanced bamboo region, shows four BSCMs to drive dynamic green transition and development trends. Some other bamboo regions shall also be analysed, in order to help more bamboo regions to explore and implement bamboo-based green-circular economic growth in particular situations.

A. Profitable Land Restoration & Energy Production

Cluster Model A is about fundamental value chains of the region, that don't require advanced bamboo cultivation and processing skills, or developed product markets.

B. Food Production, Health & Wellbeing

Cluster Model B is about healthy food production, wellbeing and cultural-tourism value chains of bamboo, bringing farmers better livelihood.

C. Technical Products & Building Construction

Cluster Model C is about widely ranged value chains of managed bamboo groves and plantations integrated in agro-forestry and nature ecosystems, supplying bamboo production units a variety of products, furniture, building-construction materials, bioenergy and infrastructure.

D. Standard, Regulation & Research Development, Trade Centres

Cluster Model D is about testing, monitoring and approving process of bamboo related standards and certifications, from culm, agro-forestry, food, fibre, homeware and construction elements, to green and infrastructural technologies etc.

Keywords: *bamboo related sectors, bamboo sectoral cluster models, spatial development, multi-actors, value chains*

Certification for bamboo sector

Maharaj Muthoo

Roman Forum, Rome, Italy

RomanForum@virgilio.it; mmuthoo@gmail.com

Abstract: Bamboos provide multiple use products-cum-commodities worth billions of dollars. It is timely to develop and deploy Bamboo Certification for valorization and quality assurance, *inter-alia*, benefiting bamboo custodians, producers, consumers, entrepreneurs and concerned communities. This calls for policy and strategic support for institutionalizing Bamboo certification systems and standards.

Categories of certification schemes pertinent to Bamboo are forest management, social, organic and product quality certification. Forest Certification mainly assesses resource management sustainability, corporate responsibility and legality, including chain-of-custody certification. Social Certification systems assure equitably shared benefits among stakeholders, involving tenure and customary rights, fair returns and adequate benefits, safe and healthy working environment, impact on indigenous and other local communities, economic viability of handicrafts, and ethical trade and marketing. Organic Certification could apply to Bamboo products gathered in and outside the forests free of chemical treatments, while wild crafted and semi-domesticated holistic production management system promote and enhance agro-ecosystem health, including biodiversity, water, soil and biological cycles. The “Certificate of Origin” for Product Quality properties evaluates physical identity and purity of raw materials, extracts and other substances, and is pertinent to bamboo shoots as well as for replacing plastics and similar unhealthy products.

Certification is getting pertinent for Bamboo renewable resource regeneration, conservation, cultivation, and contribution to Sustainable Development Goals for an inclusive green economy. Hereby propose to move forward for Bamboo certification models designed with contextual consideration of co-related issues of sustainability, human welfare, and carbon capture *et-al*.

Keywords: *bamboo certification, green economy, sustainability*

Life cycle assessment of bamboo briquette production in Iloilo, Philippines

De Leon, J.M. , Baynosa, M.L., Aberilla, J.M.*

*University of the Philippines, Diliman, Philippines
jgdeleon@up.edu.ph (*Corresponding Author)*

Abstract: Bamboo wastes are produced during the manufacturing of bamboo products (handicraft, furniture, flooring, etc.). A waste utilization method through converting bamboo waste into briquettes, as an alternative to conventional charcoal, is sought to be an environment-friendly option. This presents an opportunity for managing solid wastes, conserving forests, and providing livelihood for urban and rural communities targeting the Sustainable Development Goals 7, 8, 13, and 15. However, the production of bamboo briquettes involves carbonization which has unfavourable impacts on air, health, and the environment (deforestation and greenhouse gases emissions). When gauging the impacts of proposed alternatives to conventional charcoal, understanding the effects of carbonization is only a part of the whole process. To clearly assess the environmental impacts of bamboo briquette production, a life cycle assessment (LCA) methodology was used. It accounts the environmental impacts of a system using the standardized methodology defined in ISO 14040. There has been no record on the life cycle assessment of bamboo briquette production in the Philippines. Generally, LCA on briquette production from bamboo wastes showed promising low environmental impacts. However, based on initial results, electricity consumption and thermal process play major roles. The LCA results can determine key areas for the improvement of the different processes, determine emissions and impacts, and promote more policies to support the safe production of bamboo briquettes.

Keywords: *life cycle assessment, bamboo, briquette, biomass, waste utilization*

Bamboo and rattan (BAR) value chain in South Western Cameroon (SWC)

P. Sama-Lang¹, O.N Bessong², A.E. Makia²

*¹ University of Buea, Faculty of science, Buea, Cameroon
patricksamalang@gmail.com.*

² South West Development Authority (SOWEDA), Buea, Cameroon

Abstract: Bamboo and rattan (BAR) in Cameroon, Africa and the world is part of a growing value chain, for economic recovery. It includes the great road to Carbon neutrality, in the growing green industry. This growing green value chain needs to be carved out for economic recovery. BAR capacity to store carbon will be appreciated for potential reforestation. The place of BAR in ecosystem biodiversity will be assessed with end-users of the biosphere. Restoration of the forest especially in degrading areas using BAR assessed as part of forest conservation strategy. Green Industrial Recovery context for the BAR growing value chain identified; BAR potentials in SWC is the target. They are identified for sustainable livelihoods. Poverty, is used to characterize rural areas with BAR, as build up to green economy, supplying

raw materials. Sustainable management from BAR resources is observed as a build up in agroforestry systems for livelihoods. Smallholder units identified in small- and medium-sized enterprises show development trends observed. This is through case studies in Buea, Limbe and Bangem, respectively at the foot slopes of the Cameroon Mountain (CaM) and the Muanenguba Mountain (MaM). The result include carved out green BAR supply chains at the foot slopes of the MaM and CaM, for sustainability dialogues and negotiations, with INBAR. Projections are eminent within SWC and across central Africa. Elements for socioeconomic development identified will relate well to Cameroon, Central Africa and beyond, through the growing and carved out BAR value chains. Working with INBAR Cameroon, restitutions in SWC will be towards North western Cameroon, and by extension in to the Central African sub region and beyond, and for sustainability in general.

Keywords: *Bamboo and rattan (BAR), economic recovery, reforestation, South western Caméoon (SWC), value chain*

Ensuring monetary, human capital and natural capital returns in bamboo for biomass production

J. Wahono^{1}, H. Baral², M. Brady²*

*¹ Clean Power Indonesia, Jakarta, Indonesia
jwahono@cleanpowerindonesia.com (*Corresponding Author)*

² CIFOR, Bogor, Indonesia

Abstract: Primary energy demand in Indonesia is growing rapidly due to urbanization, economic development and population growth. The Government of Indonesia has mandated that new and renewable energy should contribute 23% of the national energy mix by 2025. Indonesia's updated Nationally Determined Contribution (NDC) stresses five sectors in which greenhouse gas (GHG) emissions are to be reduced, with land use, land use change and forestry (LULUCF) and energy being the highest priorities. While Indonesia is committed to addressing climate change through the LULUCF sector, there are clear contextual challenges that must be confronted to create the enabling conditions for REDD+, the main mechanism for carbon revenues, to contribute to landscape restoration in Indonesia. This chapter argues that biomass production for power plants in remote and isolated areas could become an additional agent of change in tackling this difficult problem. Using a case study from the Mentawai islands in Indonesia, we describe a methodology for rural electrification using a community- and biomass-based power generation system. The Mentawai model not only shows that biomass power plants can be used as the backbone for electricity generation in remote and isolated settings, but it can also be valuable tools to help alleviate poverty in underdeveloped regions in Indonesia as well as help finance the restoration of degraded and marginal lands. Replicating this system—one which results in biomass production, land restoration, affordable electricity and local economic growth—could improve the contribution of renewable energy to the energy mix and to the overall prosperity of Indonesians in rural and remote areas.

Keywords: rural electrification, biomass power plant, community based biomass production, ecosystem restoration, economic empowerment

Current situation of China's bamboo sector and the construction and development of industry-university-research platforms

Li Lan

International Centre for Bamboo and Rattan, Beijing, China

Abstract: China's bamboo sector boasts broad prospects and unlimited market potential, whose output value has grown rapidly over the past decade. However, the foundation of China's bamboo sector remains relatively weak compared with other sectors, the rich bamboo resources have yet to be fully exploited, and bamboo enterprises as a whole lack market competitiveness. In response to the problems and challenges facing China's bamboo sectoral development, two significant Industry-Education-Research platforms, initiated by the International Centre for Bamboo and Rattan (ICBR), were established. One is the China Bamboo and Rattan Brand Cluster, the other is the National Forestry and Grassland Innovation Alliance on Bamboo and Rattan Industry (CHINA). Although the purpose and commitment of the two platforms are different, they both make positive efforts in top-level design, public services, policy advices, promoting cooperation and exchange, providing data and information support, etc. They gathered the advantageous strengths of China's bamboo sector to promote technological innovation, and facilitate quality and efficiency improvement and the transformation and upgrading of the sector.

Keywords: current situation of china's bamboo sector, construction and development of industry-university-research platforms

The integrated development of the bamboo sector in Qingshen county

Liu Jinzhao

Qingshen County Committee of the Communist Party of China, Qingshen, China

Abstract: Based on President Xi Jinping's important instructions, "Sichuan should adopt suitable measures to develop the local bamboo sector, making the most out of the local advantages and characteristics, such as the Shu'nan Bamboo Sea, so that the bamboo forest can create a beautiful environment in rural areas of Sichuan Province", and the decision –making and deployment of the National, Provincial and Municipal Governments accordingly, in order to promote high-quality bamboo sectoral development, the People's Government of Qingshen County carried out the research and development on Integrated Development of the Bamboo Sector in Qingshen County. Four major actions have been taken: 1) to develop bamboo forest landscape to provide eco-services; 2) to develop a leading bamboo tissue paper industry in

Sichuan; 3) to develop bamboo weaving industry to conserve and heritage local traditional culture; 4) to organize bamboo exposition to connect Qingshen with the world. These four actions have fully reflected the integrated and harmonized development of the primary, secondary and tertiary industries of the bamboo sector in Qingshen. This presentation depicts major experiences and lessons learnt: strong organization and leadership, rational planning, scientific supports and opening and cooperation. Looking into the future, the County will push forward the upgrading of the “Bambu” tissue paper production as a pillar industry, make bamboo weaving industry a mainstreaming industry and advocate relative cultural heritages, make the local bamboo industry research institute a platform for innovation and development, making the China International Bamboo Industry Trade Expo a carrier of the opening and cooperation initiative. The Qingshen bamboo sector is targeting a 15 billion USD production value of the bamboo sector, with a cluster of bamboo enterprises, and extended bamboo supply chain, making Qingshen a model high-quality development and a bamboo art city well-known in the world.

Keywords: *bamboo industry, integrated development, famous international bamboo art city*

Innovation originating from ingenuity—replacing plastic with bamboo, accelerating green and low-carbon transformation

Lu Jiping, Ren Jingtao

Hengda Bamboo Filler Co., Ltd., Yixing, Wuxi, China

Abstract: Bamboo filler is an important substitute for plastic. This paper, starting with the birth of the Hengda Bamboo Filler Co., Ltd. against a backdrop of rural revitalization, firstly reviews the development history of cooling tower fillers, introduces the manufacturing process of bamboo filler, and describes the performance and pros and cons of bamboo filler, pointing out that bamboo filler will usher in a new development opportunity. Besides, the paper introduces the development of related industries and the background of the initiative on “Replacing Plastic with Bamboo” which was included in the list of major deliverables of the High-level Dialogue on Global Development, showing the global development potential and bright prospects of the bamboo filler sector. Furthermore, based on the introduction of relevant achievements in scientific research, this paper, combined with authoritative statistical research on carbon sinks, proves that bamboo filler, as an important substitute for plastic, is conducive to reducing plastic pollution and achieving carbon peaking and carbon neutrality goals. Finally, the paper demonstrates the enormous potential benefits of the bamboo filler sector from three levels—ecological, economic and social, and takes Hengda Bamboo Filler Co., Ltd. as an example to describe the relevant benefits.

Keywords: *replacing plastic with bamboo, bamboo filler, green and low-carbon*

Understandings of forest carbon sink promoting carbon neutrality

Xiao Wenfa

*Chinese Academy of Forestry, Beijing, China
xiaowenf@caf.ac.cn*

Abstract: Forests' function as carbon sinks and their contribution to global "carbon neutrality" has become a global consensus. The formation, promotion, monitoring, measurement, certification and trading of forest carbon sinks have become important fields of scientific research and social development. This paper analyzes and discusses several basic problems in the whole chain of forest carbon trade, including how the definitions of forests influence the carbon trade measurement, carbon source-sink relationship, carbon measurement, monitoring, project development, carbon trading and so on. This paper also analyzed the challenges, potentials and paths of forest carbon trade promotion in China, the directions of forest carbon sinks research and technological innovation system. The paper put forward the opinion that it is necessary to further optimize the social systems and regulations related with carbon cycle in forest eco-system, the design and applications of relative technologies and cultural system, in support of the national "Carbon Peaking and Carbon Neutrality Goals" and the development of ecological civilization.

Keywords: *forest carbon sinks, monitoring and accounting, carbon sink increase and emission reduction, carbon trading, scientific and technological innovation*

The bamboo and *Guadua* paradise: an integral model of ecotourism, agriculture and innovation with bamboo for Colombia

X. Londoño

*Colombian Bamboo Society, Colombia
ximelondo@gmail.com*

Abstract: The Bamboo and Guadua Paradise is a company devoted to conveying a life's passion for Guadua and bamboos through environmental educative tours, training workshops, bamboo agriculture, research and innovation. It is unique in América.

The Bamboo and Guadua Paradise boasts the extensive germplasm bank of Bambusoideae in the northwest of south America, with around 90 species from tropical lowland region of Asia, America and Africa, a 100-year-old guadua houses and several bamboo constructions, a wonderful 350- metre-long bamboo tunnel path, connectivity corridors that protect 150 plant species, 115 bird species, 6 amphibian species, 12 reptile species and 10 mammals species, water springs and swamps where bamboos are used for bioremediation and flows 4 liters of water per second after 20 years of transformation process, specialized bamboo nursery, different tropical crops (coffee, banana), reconversion of traditional crops for bamboo, and 4 ha of commercial plantations of bamboo for shoot production and for bamboo poles.

It brings considerable social and economic impacts to the local area, increasing employment opportunities through agricultural production, the establishment of new and innovative crops such as bamboo shoots, and the tourism operation. Also, we respond to 9 of the 17 SDGs.

After many years of dedication to investigating, promoting, preserving and transforming bamboo, we are convinced that bamboo can contribute to poverty alleviation in many rural areas of Colombia. The Bamboo and Guadua Paradise is an integrate model that can contribute sustainably towards the social, environment and economic progress of farming families, and to achieve peace, inclusion and equity in every corner where bamboo grows in Colombia.

Keywords: *Colombia, Guadua, ecotourism*

Seizing business opportunities in China's transition towards a nature-positive economy

C. Zhu^{1}, A. Khatri¹, Y. Hu¹, X. Lu¹, A. Semov¹, P. Zhang³, G. Yin², Y. Wang²,
Q. Wang², Q. He², X. Liu², X. Wang², X. Wang²*

¹ *Beijing Representative Office, World Economic Forum, Beijing, China
Chunquan.Zhu@weforum.com (*Corresponding Author)*

² *GoldenBee Management Consulting Co. Ltd., Beijing, China*

³ *PwC China, Shanghai, China*

Abstract: Fast economic growth and rapid urbanization rates have taken their toll on China's natural ecosystems. Natural ecosystems and their services are at the centre of China's economic growth, business prosperity and social development. The report shows that nature loss puts two-thirds of China's GDP and social development at risk. To address challenges including climate change and biodiversity loss, this report lays out a clear roadmap for Chinese companies to seize the business opportunities offered by 15 priority transitions under three socio-economic systems, namely food, land- and ocean-use system, infrastructure and built-environment system, and energy and extractives system. These transitions are projected to add \$1.9 trillion in business value and could create 88 million jobs in China by 2030. China is in a unique position to lead the transition to a nature-positive, net-zero and equitable economy as the host of the UN Convention on Biological Diversity's COP15. And China is fully committed to the principle of "ecological civilization" and has strengthened its biodiversity conservation as a national strategy. Four steps have been put forward to set China on a nature-positive pathway: 1) Promote global consensus, raise ambition and strengthen collaboration; 2) Drive policies and regulatory changes; 3) Leverage Fourth Industrial Revolution technologies and innovation; and 4) Mobilize public funds and private investment.

Keywords: *nature-positive, biodiversity, business opportunities, climate change, sustainable development*



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