生立孟宗竹之染色（第一報）－染色方法[6]

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【摘要】本報告探討以高親和力鹽基染料染著生立孟宗竹之方法。將適量的染液（濃度0.5～1.0%）由節間上端的小孔注入，染液則因光合作用與蒸散作用經由接近節間底端的斜切口擴散至維管束並染色。本文所提方法之作業簡單、便宜、不須特殊的設備並可在竹林現場完成。染著生立孟宗竹之效果隨不同季節之蒸散作用而異。本文所提染色法期能提供孟宗竹更佳的利用性。

【關鍵詞】生立孟宗竹、染料、染色方法、光合作用、蒸散作用

Living Moso Bamboo Dyeing Part 1. Dyeing Technique[6]

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【Abstract】This paper is a way to dye the living Moso bamboo with some high-affinity basic dyestuffs. Optimum amounts of dye solution (conc. 0.5-1.0%) were injected in to a small hole drilled in the upper end of internode, and then the dye solution will diffuse into the vascular bundles by way of a cut slot near the lower end of internode by photosynthesis and transpiration. In addition, this technique is simple, cheap, does not require special equipment and can be carried out in forest or other remote areas. Treatment schedules for different seasons with varying tanspirations have to be worked out. This technique can be developed for better Moso bamboo utilization .

【Key words】Living Moso bamboo , Dyestuffs , Dyeing technique, Photosynthesis, Transpiration

Ⅰ.INTRODUCTION

The bamboo culm is cylindrical in shape, usually hollow inside, and is divided into nodes from which branches arise. At each node there is a diaphragm which separates the cavity of one internode from the next.

The culm material, built up of parenchyma cells and vascular bundles, contain about 50% parenchyma, 40% fibers and 10% conducting cells (vessels and sieve tubes) all oriented axially (kollman and wilfred,1967). Parenchyma and conducting cells are more frequent in the inner part of the wall whereas the peripheral zone is mostly fibers (Fig.1.). There are no ray cells in bamboo for radial transportation of sap.

Bamboo is a renewable resource with a short crop rotation period of 3-5 years depending on species and locality. Bamboo is used for building

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constructions, scaffolding, fencing, ladders, poles, furniture, mats, basket and for numerous other purposes. Moso bamboo with its round shape and stiff strength is the mostly common used bamboo species in Taiwan bamboo industry for years. However, due to the increasing labor cost and lack of laborer, it seems likely no profit for the bamboo crop. The aim of this study tries to increase the profitability of Moso bamboo farmers by suitable living bamboo dyeing technique.

II. EXPERIMENT

Moso bamboo (*Phyllostachys pubescens* Mazel) age is over 3 years with 10-12 cm in D.B.H and 13-16m in height. The site conducted is in Huisun experimental forest station, which is located in the northern part of Nantou county. Huisun experimental forest station is characterized by its altitude of 700 m, unfertilized and acidic type of soil.

Three different dyes (basic dyes, acid dyes and direct dye) charges (0.5 and 1.0 %) were tested, alum, Na_2S0_4 and NaCl were used as fixing agents for acid dyes (conditions see Table 1). Immersing bamboo split (30 cm (length) × 2.5 cm (width) × 0.2 cm (thickness)) into dye solution (conc. 0.5%) for two hours at 20℃ by chromatography to test the dyeing properties of each dyestuff. Report the rising height in 2 hours and the extent of coloring (expressed as even, uneven or poor) as the coloring strength (or diffusive rate).

Injecting 300-500 ml dye solution through a small drilled hole (Fig.2), which is 40 cm above the ground, into the cavity and then sealing the small hole to allow dyes flow through the cut slot located on the lower port of internode axially by photosynthesis for one week. As for gaining the insight on the dyeing effect , took pictures of the cross section of the dyed bamboo with Stereo microscope (× 50) with color Video Camera (SEN. TECH. STC-70. Japan) as well.

III. RESULTS AND DISCUSSION

(I) Dyeing technique

Too often in wood and bamboo preservative, diffusion treatment and pressure impregnation processes have been commonly used. However, these methods only confined to log, sawn timber, veneer etc., of which are non-living materials. Unfortunately, the void volume of wood and bamboo mostly occupied by the air with high surface tension after cutting, so the air-filled voids prevent the ease of fluid flow in dried wood and bamboo. The conduction and distribution of aqueous solutions as well as the exchange of cell contents within the living part of wood are only made possible by the presence of openings i.e., pits and bordered pits in the cell walls. Since the structural elements of Moso bamboo mostly aligned in longitudinal direction, the dye solution flows through the vessels in y-axis more easily than in radial direction (Dietrich and Gerd,1983). Dye solution can not diffuse into the whole part of bamboo culm effectively is the most encountered problem in diffusion treatment, due to the high-surface tension air presents in the pores of dried bamboo. Based on the above statement, we intend to develop a useful technique to dye the bamboo culm during its growth period instead of the conventional method.

Fig.2. shows the dyeing technique as the cutting slot on the bottom of an internode to allow the dye solution to flow through the longitudinal conducting tissues by photosynthesis and transpiration. It can be recognized that in an ideal treatment, the depth in the Moso bamboo to which a given concentration (0.5%) of dye solution has reached should be related to the following factors:

▲Solubility of the dye particle in the sap of bamboo tissue.

▲ Coloring strength of dyestuffs i.e., the affinity of dye to constituting components such as lignin, cellulose etc. in bamboo.

▲ Some changes in the photosynthetic properties or transpiration of bamboo leaves grown in various seasons, which might affect dyestuff (soluble in water) uptake through conducting tissue cells (Lincoln and Eduardo,1991).

An interesting result is obtained when you see the micrographs (Fig.3a and 3b.) in the cross section of dyed Moso bamboo showing the dyed portions are mostly found in the vascular bundle other than parenchyma cells of ground tissue. In addition, the less dyed diffusion area is near the outer epidermis for both of the dyestuffs, probably due to the dense tissue of outer layer makes the dyestuff penetrating impossible.

(II) Dyestuff selection

Selection of suitable colorants is a function of end-use requirements, eye appeal and base for bamboo converting. The commonly used colorants in wood coloring are basic dyes, acid dyes and direct dyes (Casey,1981). They differ even within a class as to value, solubility, substantivity and fastness properties, and each colorant has certain advantages and limitations. Most colored bamboo is dyed with soluble dyes. This study is limited to water-soluble dyes.

Table 1 shows 0.5% basic violet dye has a strong affinity for lignin and other noncellulosic parts of the fiber in living bamboo than acid and direct dyes in one-week dyeing period. Basic dyes are bright and have high tinctorial value and hence suitable to use.

In order to differentiate the dyeing properties of various dyestuffs, immerse bamboo splits (30 × 2.5 × 0.2 cm) into the dye solution (conc. 0.5%) for 2 hours to see the dyeing results by chromatography. Table 2 shows basic violet dye, acid blue and basic blue dyes' ethanol solution have good and even coloring effects. It seemed that ethanol with less polarity and low boiling point might help dyes diffuse into the bamboo more deeply when compares to water. Except the conducting tissue in culm, dyes can not diffuse into the culm through the inner wall membrane next to the cavity.

(III) Diffusive rate of dyestuffs

Although the living bamboo dyeing method has the advantages of ease of operation and thorough dyestuff diffusion into bamboo culm, it is interesting to note the diffusive rate of selected dyestuffs for better use as dyed bamboo. The living bamboo is treated and there is usually no need to segregate sizes. Dyestuff diffusion (or penetration) can be obtained at ambient environment and by photosynthesis and transpiration. Being water soluble, the dyestuffs can be transported through the sap of bamboo tissue and dyed in ionic form.

Fig.4. shows the diffusive rate of basic violet dyestuff in the culm of living Moso bamboo. In winter, the initial 3 hrs' diffusion period had the lowest diffusion rate (low slope). The following 2 hrs (3rd-fifth hour) showed a moderate slope, and this period had an increasing diffusion rate. 5-6 hour period with the highest slope gave the highest diffusive rate in one day. It had about 6℃ temp. difference (15 - 9℃) between 10:00 a.m. and 18:00 p.m. while we were carrying out this experiment in February . In spring, higher diffusive rate were noted for the higher temperatures (29-25℃ (13:00 - 15:00 p.m.). Temperature and light affect all the

biochemical reactions of photosynthesis. Therefore it is not surprising that the responses (diffusive rate of dyestuff) to temperature are complex.

(IV) Utilization of dyed living Moso bamboo

Moso bamboo is a renewable resource with a short crop rotation period of 3-5 years. Except its yellowish color in nature, miscellaneous dyed living bamboo can be used as good raw materials for the manufacture of bamboo handicrafts as indicated in Fig. 5a, 5b and 5c, respectively. The colorful striped bamboo can be used as numerous purposes, such as furniture, pen box, over lay veneer of the plywood, carving material and flowerpot.

Of course, we need further studies to have incentive utilization of dyed living Moso bamboo in the near future.

IV. CONCLUSIONS

The suitable living Moso bamboo dyeing method found in this study is cutting a slot at the bottom of an internode and then seal it immediately, thereafter injecting the prepared dye solution through a small hole near the upper end of the same internode. Basic dyes with good affinity with bamboo components have admirable dyeing effect in vascular bundles by diffusion from photosynthesis and transpiration during a period of rapid growth.

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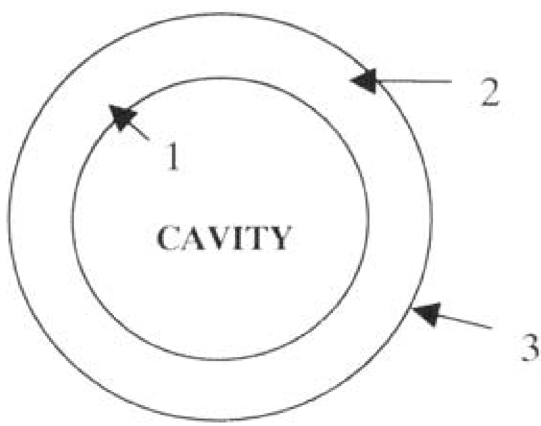

1.Inner layer mainly consists of parenchyma cell and transport tissues
2.Outer layer mainly consists of fibers
3.Hard bamboo epidermis

Fig. 1. Cross section of Moso bamboo culm.

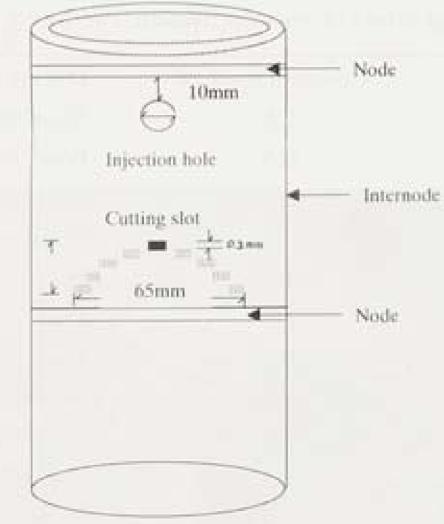

Fig. 2. A graph illustrating the dyeing method for living Moso bamboo.

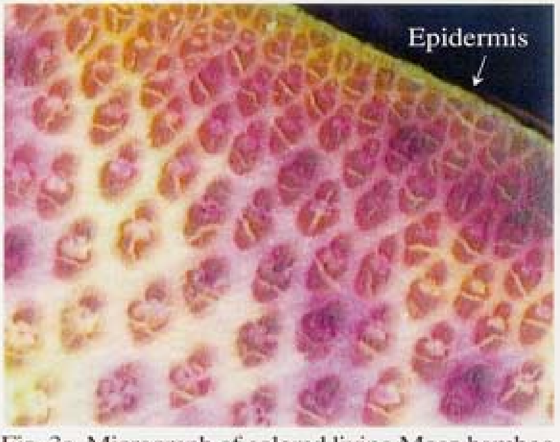

Fig. 3a. Micrograph of colored living Moso bamboo (cross sec. × 50) dyed with basic violet dye.

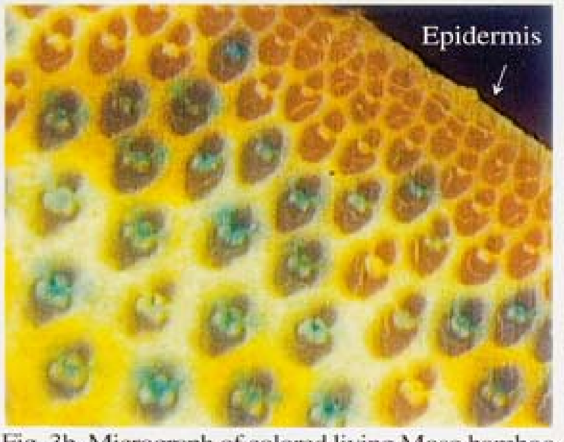

Fig. 3b. Micrograph of colored living Moso bamboo (cross sec. × 50) dyed with basic green dye.

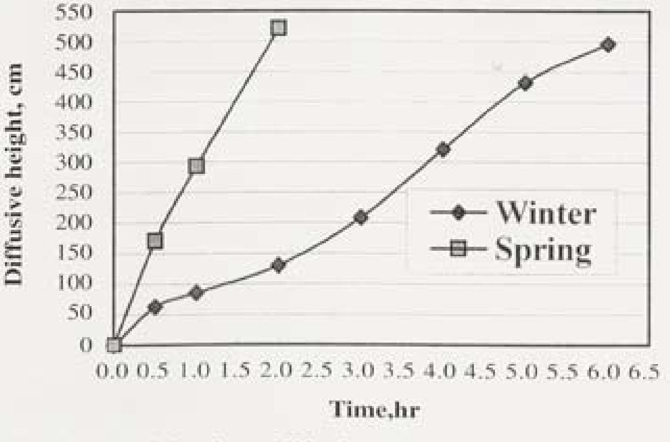

Fig. 4. Diffusive rate of basic violet dyestuff in the culm of living Moso bamboo at different seasons.

Table 1. Dyeing effect of various dyestuffs in living Moso bamboo in one week.

Dyestuffs	Concentration, %	Dyeing effect
Basic Violet	0.5	Excellent, staining to the branch
Basic Blue	0.5	Poor, staining to 435 cm height of culm
Basic Green	0.5	Excellent, staining to the branch
Basic Golden Brown	0.5	Excellent, staining to the branch
Direct Sky Blue	1.0	Poor
Direct Red	1.0	Poor
Acid Blue	0.5	Poor, staining to 94 cm height
Acid Blue + 2%Alum	0.5	Poor, staining to 126 cm height
Acid Red + 3% Na_2SO_4	0.5	Poor, staining to 143 cm height
Acid Red +0.5% NaCl	0.5	Poor, staining to 92 cm height
Acid Violet	0.5	Poor, staining to 316 cm height

Table 2. Splitting bamboo culm chromatography for various dyestuffs.

Dyestuffs	Dyeing results
Acid Blue (0.5%)	Uneven coloring , staining to 8 cm height
Acid Blue (0.5%) + ethanol (4:1 v/v)	Even coloring , staining to 10 cm height
Basic Violet (0.5%)	Even coloring, staining to 11 cm height
Basic Blue (0.5%)	Uneven coloring, staining to 5 cm height
Basic Blue (0.5%) + ethanol (4:1 v/v)	Even coloring, staining to 7.5 cm height

Size of splitting bamboo culm : 30 cm (L) x 5cm(W) x 2cm(T)
Immersion time : 2 hours
Length of sample immersing in dye solution: 1.5 cm
Temperature of dye solution : 20 ℃

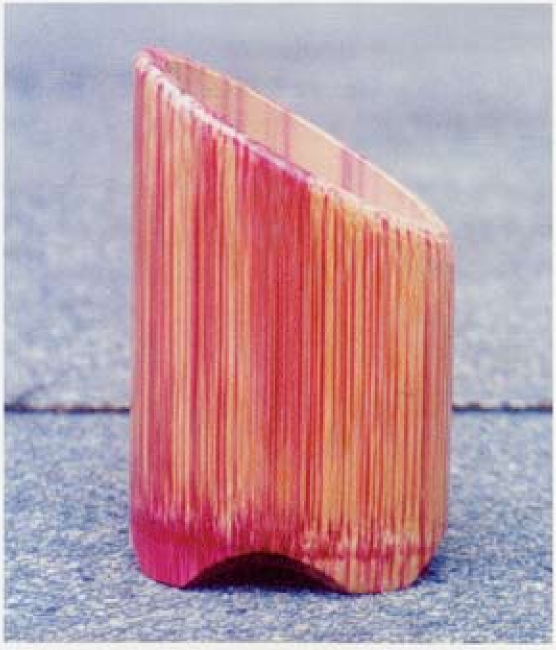

Fig. 5. Colored living Moso bamboo specimens.
Fig.5a.Bamboo Pen containers with colorful stripes in longitudinal direction.

Fig. 5b. Colored bamboo flower utensil.

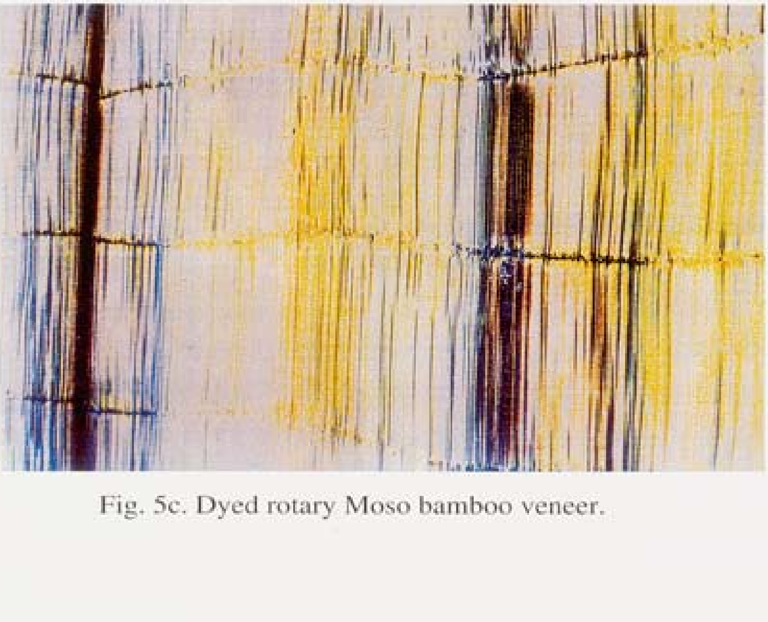

Fig. 5c. Dyed rotary Moso bamboo veneer.