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Effect of light intensity and rooting hormone on propagation of *Bambusa vulgaris* Schrad ex Wendl. by branch cutting

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Abstract—Untreated and treated (with 0.2% solution of rooting hormone IBA) branch cuttings of *Bambusa vulgaris* Schrad ex Wendl. were allowed to root under four different light regimes, *viz*., open sun, tree shade, partial shade and deep shade. Rooted cuttings were then grown under the open sun for 6 months to assess the performance of stecklings. Rooting ability of cuttings and growth performance of stecklings were found affected significantly both by light intensity and IBA treatment. Highest rooting percentage (84%) was in IBA treated cuttings rooted in the tree shade followed by untreated cuttings under the same light regime (73.3%) and the lowest (60%) was under the deep shade. The number of roots per cutting was also the highest (7.9) in the treated cuttings rooted under tree shade and the lowest (4.1) for untreated cuttings grown under the open sun. However, the longest root was in cuttings rooted under tree shade (17.1 cm) without IBA and the shortest (9 cm) was in deep shade regime. The highest survival percentage was 95.2% in treated cuttings rooted in the open sun and the lowest was in case of deep shade without IBA treatment, while maximum number of shoots were developed in treated cuttings rooted under tree shade. Shoot length was the highest in treated cuttings rooted under partial shade.

Key words: *Bambusa vulgaris*; branch cutting; light intensity; rooting hormone; steckling.

INTRODUCTION

With 75 genera and 1250 species around the globe [1], bamboo belongs to the subfamily *Bambusoideae* of the family *Poaceae*. In the Indian subcontinent, it is known as 'the poor men's timber'; in China as 'friend of people' and in Vietnam as 'brother of people' [2]. In Bangladesh, 33 species of bamboo have so far been found, of these 7 occur naturally in forests and the rest are cultivated in homestead throughout the country to fulfil day-to-day needs of village people [3]. *Bambusa vulgaris* is a

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widely grown village bamboo in rural areas of Bangladesh and it has multiple uses. This bamboo is 10–35 m long, thick walled with glossy green culm (5–10 cm in diameter) at juvenile stage and yellowish when old or on exposure to the sun. It usually branches throughout the stem, except 3–6 basal nodes with brown to whitish root rings.

B. vulgaris does not seed after flowering [4] and, therefore, no seedling progenies are available [5], i.e., it could be propagated only vegetatively [2, 6]. Available methods for vegetative propagation of *B. vulgaris* are rhizome cutting, offset planting, culm or stem cutting, pre-rooted branch cutting and ground layering, with disadvantages like season specificity, lower multiplication rate, skill demanding or capital intensiveness. Rhizome cutting is the most popular vegetative propagation method among the village cultivators but bulky size and heavy weight (4–30 kg) of rhizomes rendered it costly, since high labour cost is involved in excavating and transporting propagules. In addition, the survival potential of rhizome cutting is not always satisfactory and clumps loose their regeneration potential if more rhizomes (3–4) are excavated from a single clump. Another problem is the availability of offsets in limited number. On the other hand, the main disadvantage of culm cutting is non-applicability for species with long internodes and very low survival potential. bending the culms of tall bamboo species on the ground is too cumbersome in case of layering [2]. Pre-rooted branch cuttings can be made only during the wet seasons and only a few of the branches attached with the mother culms develop root at their base which makes it inapplicable for round the year for large-scale plantation establishment.

The recently developed branch-cutting technique has solved most of these problems [7] as it is inexpensive without seasonality, produces a lot of propagation materials with high survival potential and reduces damage and transportation cost [2]. A branch, one node from the main branch and 3–4 nodes from secondary branches, is used to cut for propagation. The cuttings start producing active buds within 7–10 days and produce profuse active roots in the propagation beds within 4–8 weeks, depending on the season [2].

Successful rooting of branch cuttings depends on optimization of endogenous and exogenous factors associated with inherent capacity for propagation, collection of source materials, preparation and treatment of cuttings, method of propagation, adjustment of optimum condition for rooting, treatment of stock plants and their management [8].

Low light intensity is believed to enhance rooting ability of cuttings of vascular plants [9, 10]. Applied auxin significantly increases both the rooting percentage and number of roots in bamboo stem cuttings [11–13]. Low light intensity along with auxin treatment intensifies the rooting ability of cuttings in a number of hard-to-root tree species. Several studies [9, 10, 14] have examined the effect of light intensity and rooting hormone IBA on rooting ability of cuttings of vascular plants but their effect on rooting ability of the branch cutting of bamboo has been dealt less intensively. Pattanaik *et al.* [15] reported the positive effects of rooting hormone

IBA (200 ppm) on the rooting of two noded branch cuttings of *B. balcooa* Roxb. The current study examined the effect of light intensity and IBA treatment on rooting ability of branch cutting of *B. vulgaris*, as well as the performance of the resultant stecklings under nursery conditions.

MATERIALS AND METHODS

Study area

The study was conducted over a period of one year from July 2003 to June 2004 in the nursery of the institute of Forestry and environmental sciences, Chittagong University, Bangladesh. It lies at 22°27′27″ N latitude and 91°48′30″ E longitude and enjoys typical tropical monsoon with hot humid summer and cool dry winter having a mean monthly temperature between 21.8 and 29.2°C, the maximum and minimum being 26 and 15°C, respectively. Relative humidity is the lowest (64%) in February and the highest (95%) in June to September and mean annual rainfall is about 300 cm, which occurs mostly between June and September. Mean monthly day length varies between 10 h 35 min in December and 13 h 20 min in June.

Preparation of cuttings

For cutting, branches, 2 years old or younger, were collected from pre-selected healthy vigorous clumps in July 2003. Leaves, auxiliary branches and tops of the collected branches were trimmed carefully. For propagation, cuttings were made with special care so that no splitting occurs at the cut end. One node on the primary branch was kept with approximately 3 cm of stem on both the sides of the node. The secondary branch had 3 to 4 nodes on it; however, in case of a shorter internode secondary branches with 5 nodes were taken (Fig. 1). The higher the numbers of nodes on the cutting, the greater is the chance of rooting [2]. The average length and diameter of the cuttings were kept relatively unchanged to avoid non-treatment variations. The average length of the cuttings varied between 42.5 cm and 48.4 cm where the diameter was in-between 5.8 mm and 7.3 mm (Table 1). Cuttings were wrapped with moist gunny bags immediately after segmentation and were kept in moist place to minimize water loss through cut ends.

IBA treatment

Cuttings were immersed briefly into a solution of fungicide, Diathane M45 (Rohm, France; 2 g/l water) to check fungal infection. Then they were rinsed and kept in open air under shade for 10 min. For each light regime 60 cuttings were then treated with 0.2% IBA solution by dipping the base of the cuttings into 0.2% IBA solution for 5 min. Also, for each light regime, 60 cuttings were kept as control, i.e., without IBA treatment.

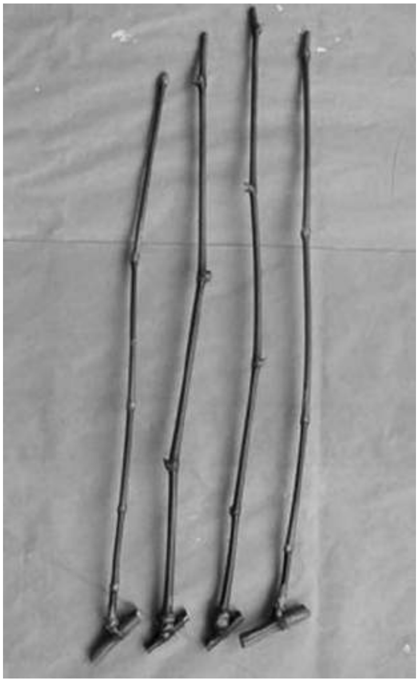


Figure 1. Branch cuttings of *B. vulgaris* ready for rooting.

Table 1.
Effect of various light intensity and IBA solution on the rooting ability of *B. vulgaris* branch cuttings

Variable	Open sun		Tree shade		Partial shade		Deep shade		Probability	
	T_0	T_2	T_0	T_2	T_0	T_2	T_0	T_2	Light	IBA
Rooting percentage	66.7^{b*}	65^{b}	73.3^{ab}	84^{a}	65^{b}	73^{ab}	60^{c}	60^{c}	0.000	0.03
Root number	4.1^{c}	6.8^{b}	6.6^{b}	$7.\ 9^{a}$	5.9^{c}	7.3^{ab}	5.7^{c}	7.5^{a}	0.000	0.000
Root length (cm)	16.7^{a}	11.1^{c}	17.1^{a}	10.8^{c}	14.3^{b}	9.2^{c}	13.3^{b}	9^{c}	0.000	0.000

* Means followed by the same letter (s) are not significantly different at $P < 0.05$, according to Duncan's Multiple Range Test (DMRT). T_0, cuttings without IBA treatment; T_2, cuttings treated with 0.2% IBA solution.

Rooting trial

The experiment, thus, was conducted with 480 cuttings in total, which were planted, vertically or slantingly, in the perforated plastic trays filled with 12 cm deep rooting media composed of a mixture of coarse sand and gravel (Fig. 2). Each tray contained 10 cuttings and two trays made up a plot, i.e., there were three replications per treatment consisting of 20 cuttings each. After planting, these trays were put under four different light regimes, open sun, tree shade, partial shade and deep shade, to study the effect of varying light intensity on the rooting ability of the cuttings.

Figure 2. Cuttings in rooting media, coarse sand mixed with small gravel in perforated plastic tray.

A shed was built by thatched bamboo for controlling two levels of shades, partial and deep. The roof and four sides of the shed were lined with small diameter (2–3 cm) bamboo sticks. Bamboo slats (20 cm wide), spaced 20 cm apart from each other, lined the sides and roof in the case of partial shade. For deep shade, the roof was further lined with bamboo mats and the sides were covered with blue polythene sheets. Cuttings were kept under large *Anthocephalus chinensis* trees to provide tree shade.

Photosynthetic photon flux was measured for a single day with clear sky using data logger (Datahog2, SDL5360, Sky Instrument, UK), quantum sensor (SKP 215 Sky Instrument) and red to far-red ratio sensor (SKR 110, Sky Instrument). The photon flux experienced by the cuttings was around 21 mol/m^2 per day under open sun. The radiation received by cuttings placed under tree shade, partial shade and deep shade was 75, 60 and 12%, respectively, compared to that received under the full sun. The partial shade regime allowed direct sun light in the form of sun patch and sun flecks particularly at midday. Red to far-red ratio was around 1 : 1.2 under full sun, about 1 : 0.95 under tree shade, 1 : 0.8 in partial shade and 1 : 0.60 in deep shade.

The cuttings were watered thrice a day till the rooted cuttings were transferred into polybags. The cuttings started to produce leaves and branches within 7–10 days and well-developed roots within 2–6 weeks.

Transfer of rooted cuttings

After 6 weeks, the rooted cuttings were transferred to polybags (15.24 cm $\times$ 12.7 cm), which were filled with soil and decomposed cow dung at a ratio of 3 : 1. Then, to assess the growth performance of propagules, they were kept under shade for one week before being exposed to the open sun in the nursery bed. Rooting percentage, root number and root length of the rooted cutting were recorded during transplanting the cuttings 6 weeks after setting. Survival percentage, number of shoot developed and height of the largest shoot of the cuttings were measured 6 months after transplanting of the rooted cuttings into the polybags.

Data analysis

All the experimental data were then analyzed statistically by using standard statistical package, SPSS. Analysis of variance (ANOVA) and Duncan multiple range test (DMRT) were made to explore the treatment variations.

RESULTS AND DISCUSSION

Rooting ability of branch cuttings

Rooting percentage. Rooting percentage was affected significantly both by light intensity and rooting hormone IBA. For different light regimes, the rooting percentage of cuttings ranged from 60 to 73.3 without IBA and from 60 to 84 with treatment by 0.2% IBA solution.

Rooting percentage was the highest in IBA-treated cuttings rooted under tree shade (84%) followed by untreated cuttings for the same regime (73.3%) and the lowest (60%) was in treated and untreated cuttings rooted under deep shade (Table 1 and Fig. 3). Although the effect of light intensity on rooting ability of *B. vulgaris* branch cutting has not been dealt in earlier literature, Various groups (see, for example, Refs [6, 9, 10, 16–19]) reported higher rooting percentage in vascular stockplants under low irradiance compared with high irradiance which might be due to low carbohydrate or starch content in stock plants grown under low irradiance [19] which may also be true in case of *B. vulgaris* in this experiment.

Rooting hormone IBA is known to influence rooting percentage of *B. vulgaris* cuttings. Sharma [20] reported that hormone treatment accelerates the success of bamboo cuttings and that it was 80% in *B. vulgaris.* Somashekar *et al.* [21] reported a maximum rooting percentage (85% in leafy branch cuttings with tip and 80% in nodal cuttings) in cuttings treated with 2500 ppm IBA. In case of *B. balcooa*, treatment with 200 ppm IBA gave 66.7% success in rooting and rhizome formation [15]. Surendran and Seethalakashi [22] found growth regulators (IBA and NAA) to enhance rooting and sprouting responses of bamboo species significantly. For *B. balcooa*, *D. hamiltonii* and *B. vulgaris* the best result was observed in case of treatment with IAA and kinetin, and for *B. tulda*, *B. pallida* and *T. dullooa*

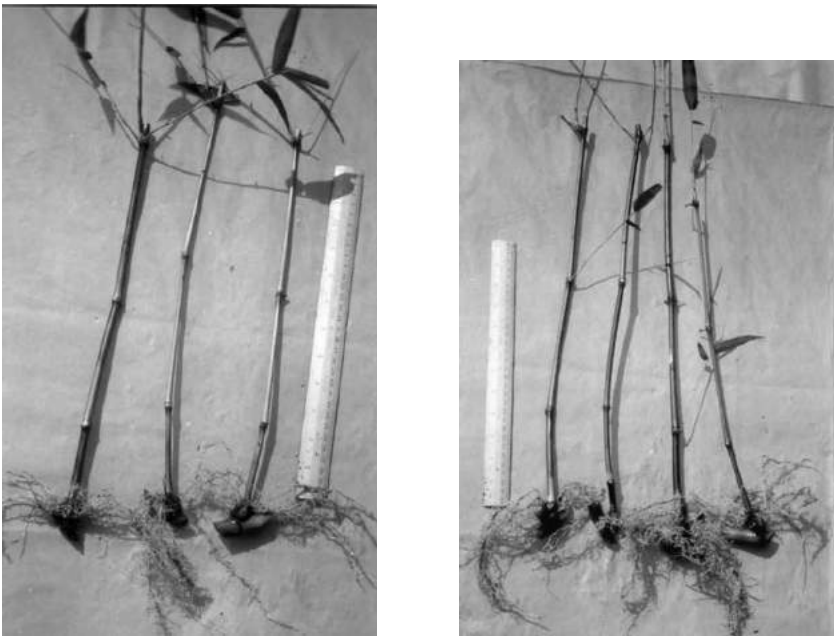


Figure 3. Cuttings rooted 6 weeks after setting in tree shade regime without (left) and with (right) 0.2% IBA solution.

while treated with NAA and kinetin [23]. Nagarajaiah, *et al.* [24] reported the potent of IBA in increasing survival, rooting and sprouting of stem cuttings of *B. vulgaris*. Findings of the current study confirm their results and in addition to theirs it observed that the effect IBA is aggravated if the cuttings are kept under moderate light intensity. So it is supposed be better to consider the rooting ability of branch cuttings of *B. vulgaris* in combined context of light intensity and hormone treatment to get the best result.

Root number. The number of roots developed per cutting was influenced significantly both by varying light levels and IBA treatment. Among all the types, mean root number ranged from 4.1 to 6.6 in cuttings without IBA treatment and from 6.8 to 7.9 in cuttings treated with 0.2% IBA solution 6 weeks after setting. The highest number of roots per cutting (7.9) was obtained in the cuttings rooted under tree shade treated with IBA (0.2%) and the lowest (4.1) was in the cuttings rooted under the open sun without IBA treatment (Table 1 and Fig. 3). To confirm the results no parallel study was found. Further investigation is needed to conduct in this aspect.

Root length. The effect of different light regimes as well as IBA treatment on root length of the cuttings was also significant. After 6 weeks of setting, the mean root length ranged from 13.3 cm to 17.1 cm in untreated cuttings and from 9 cm to 11.1 cm in cuttings treated with 0.2% IBA, irrespective of light regime. The highest length of root (17.1 cm) was observed in untreated cuttings kept under tree shade and the lowest (9 cm) in the cuttings grown under deep shade with 0.2% IBA treatment (Table 1 and Fig. 3).

Steckling performance

Survival percentage. Survival percentage was the highest (95.2) in cuttings rooted under open sun treated with 0.2% IBA followed by those under the same light regime without IBA treatment (90) and the lowest (65) was in cuttings rooted under deep shade without IBA treatment (Table 2 and Fig. 4). Survival percentage was significantly influenced both by IBA treatment and exposure to different light regimes during rooting. The result is supported by the findings of Pattanaik *et al.* [15], who reported 100% field survivals of *B. balcooa* cuttings treated with 200 ppm IBA 2 years after field planting.

Number of shoots developed in cuttings. Light regimes and IBA treatment significantly affected the number of shoots developed per cutting. Average number of shoots from each cutting was maximum (19) in the cuttings treated with 0.2% IBA and rooted under tree shade followed by those under open sun without IBA treatment (15) and the lowest (7) was in the cuttings rooted under partial shade without IBA treatment. Mean shoots number ranged from 7 to 15 in cuttings without IBA under different light levels. Mean shoot numbers ranged from 10 to 19 in cuttings treated with IBA (0.2%) and rooted under different light levels (Table 2).

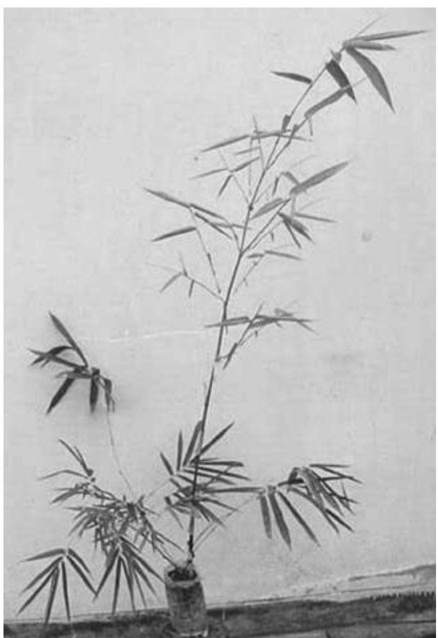
Shoot height. Maximum shoot height (124.3 cm) was observed in the cuttings treated with IBA and rooted under partial shade followed by cuttings under open sun (116.3 cm) treated with the same and lowest in the deep shade (83.3 cm) with IBA treatment. Light levels and IBA treatment significantly influenced vertical increment of the shoots. Mean vertical increment of shoots of the rooted cutting ranged from 72.3 to 114 cm in the cuttings without IBA treatment under various

Table 2.
Steckling capacity of rooted cuttings of *B. vulgaris* 6 months after transfer to the polybags

Variable	Open sun		Tree shade		Partial shade		Deep shade		Probability	
	T_0	T_2	T_0	T_2	T_0	T_2	T_0	T_2	Light	IBA
Survival percentage	90^{a*}	95.2^{a}	83.6^{b}	81.3^{b}	80^{b}	86.4^{b}	65^{c}	75^{bc}	0.000	0.000
Shoot number	15^{b}	14^{b}	13^{b}	19^{a}	7^{c}	15^{b}	10^{c}	10^{c}	0.003	0.007
Maximum height (cm)	90^{c}	116.3^{a}	114^{a}	105.6^{b}	72.33^{d}	124.3^{a}	85.7^{c}	83.3^{c}	0.002	0.000

Means followed by the same letter (s) are not significantly different at $P < 0.05$, according to Duncan's Multiple Range Test (DMRT). T_0, cuttings without IBA treatment; T_2, cuttings treated with 0.2% IBA solution.

(a)



(b)

Figure 4. Rooted cuttings grown in open sun (a) and propagules ready for out planting (b) 9 months after transfer to polybags.

light regimes and from 83.3 to 124.3 cm in cuttings treated with (0.2%) IBA (Table 2 and Fig. 4).

CONCLUSION

Rooting ability in terms of rooting percentage, root number and root length of *B. vulgaris* branch cutting was found best in cuttings treated with 0.2% IBA and rooted under tree shade. Steckling capacity considering survival percentage and number of shoots were found best in the moderate (tree shade) to full sun (open sun) regimes. Again, IBA-treated cuttings were more efficiently survived than the controlled cuttings in stecklings' performance. Thus, the branch cuttings rooted in the moderate light intensity (tree shade) with 0.2% IBA treatment may be recommended for mass propagation of *B. vulgaris* while deep shade should be avoided.

REFERENCES

1. T. R. Soderstrom and R. P. Ellis, *The Woody Bamboos (Poaceae: Bambusacea) of Sri Lanka: A Morphological and Anatomical Study*, *Smithsonian Contribution, No. 72*. The Smithsonian Institute, Washington, DC (1987).
2. R. L. Banik, *Silviculture and Field Guide to Priority Bamboos of Bangladesh and South Asia*. Bangladesh Forest Research Institute, Chittagong, Bangladesh (2000).
3. R. L. Banik, Propagation of bamboo by clonal methods and by seed, in: *Bamboo Research in Asia*, G. Lessard and A. Choumard (Eds), pp. 139–150. IDRC and IUFRO, Ottawa (1980).
4. R. L. Banik, Flowering in biajja bansh (*Bambusa vulgaris*). Letter to the editor, *Bana Biggyan Partika* **8** (1–2), 90–91 (1979).
5. F. A. McClure, *The Bamboos, A Fresh Perspective*. Harvard University Press, Boston, MA (1967).
6. K. C. Koshy and P. Pushpangadan, *Bambusa vulgaris* blooms, a leap towards extinction? *Current Science* **72** (9), 622–624 (1997).
7. K. K. Seethalakshmi, C. S. Venkatesh and T. Surendran, Vegetative propagation of bamboos using growth promoting substances-1, *Bambusa balcooa* Roxb., *Indian Journal of Forestry* **6** (2), 98–103 (1983).
8. M. Kamaluddin, Current status of clonal forestry in the tropics and its potential application in Bangladesh, Dissertation for Master of Science in Resource Management. University of Edinburgh, Edinburgh (1988).
9. A. Poulsen and A. S. Andresen, Propagation of *Hedera helix*: influence of irradiance to stockplants, Length of internode and topophysis of cutting, *Physiology of Plants* **49**, 359–365 (1980).
10. M. A. Hossain and M. Kamaluddin, Effects of lateral shading on growth and morphology of shoots and rooting ability of Jackfruit (*Artocarpus heterophyllus* Lam.) cuttings, *Journal of Applied Horticulture* **6** (1), 35–38 (2004).
11. S. Singh, S. A. Ansari and P. Kumar, Clonal propagation of *Bambusa nutans* through culm and culm-branch cuttings, *Indian Forester* **128** (1), 35–40 (2002).
12. A. Kumar and M. Pal, Mass propagation of *Bambusa tulda* through macro-proliferation for raising industrial and commercial plantations, *Indian Forester* **120** (2), 152–157 (1994).

13. K. Agnihotri and S. A. Ansari, Adventitious rhizogenesis in relation to seasonal variation, size of culm branch cuttings and IAA treatment in bamboos, *Indian Forester* **126**, 971–984 (2000).
14. V. Rpetti, Propagation of *Eucalyptus stellulata* using etiolation, *Mededelingen van de Faculteit Landbouwwetenschappen, Universiteit Gent* **58** (3A), 937–941 (1993).
15. S. Pattanaik, P. Das, E. Borah, H. Kaur and K. Borah, Vegetative multiplication of *Bambusa balcooa* Roxb. using branch cuttings, *Journal of Bamboo and Rattan* **3** (4), 365–374 (2004).
16. B. K. Maynard and N. L. Bassuk, Stock plant etiolation, shading, and banding effects on cutting propagation of *Carpinus betulus*, *Journal of the American Society for Horticultural Science* **117** (5), 740–744 (1992).
17. L. H. Stromquist and J. Hansen, Effect of auxin and irradiance on the rooting of cuttings of *Pinus sylvestris, Physiology of Plants* **49**, 346–350 (1980).
18. R. R. B. Leakey, The capacity for vegetative propagation in trees, in: *Attributes of Trees as Crop Plants*, M. G. R. Cannell and J. E. Jackson (Eds), pp. 110–133. Institute of Terrestrial Ecology, Abbots Ripton (1985).
19. K. Migita and G. Nakata, Effect of the light supply before taking cuttings on the rooting of *Cryptomeria japonica*, *Journal of Agricultural Science* **23** (1), 52–58 (1978).
20. Y. M. L. Sharma, Bamboos in the Asia-pacific region, in: *Bamboo Research in Asia*, G. Lessard and A. Chouinard (Eds), pp. 99–120. IDRC and IUFRO, Ottawa (1980).
21. P. V. Somashekar, R. N. Lakshmikanth, T. S. Rathore, K. S. Reddy and A. C. Lakshman, Macro-propagation of *Guadua angustifolia* Kunth-An exotic and fast growing Bamboo species, *Indian Forester* **130** (6), 655–662 (2004).
22. T. Surendran and K. K. Seethalaksmi, Investigation on the possibility of vegetative propagation of bamboos and reeds by rooting stem cuttings, *KFRI Research Report* **31**, 1–47 (1985).
23. M. Nath, U. Phukan, G. Barua, M. Devi, B. Barua and P. C. Deka, Propagation of certain bamboo species from chemically treated culm cuttings, *Indian Journal of Forestry* **9** (2), 151–156 (1986).
24. C. Nagarajaiah, N. S. Rao, Dasappa and K. Pankaj, Propagation of bamboo (*Bambusa vulgaris* Sch.) using growth regulating substances. Special issue: Focus on vegetative propagation, *Indian Forester* **120** (2), 180–182 (1994).