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MASS PROPAGATION OF *DENDROCALAMUS ASPER* BY BRANCH CUTTING

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Dendrocalamus asper is a thick-walled bamboo species widely used for edible shoots, chop sticks, rural housing, structural and building construction, ornamental and ecotourism purposes in Malaysia. However, due to the declination of timber production, increasing human population and their ever increasing demand, natural bamboo stands will not be able to cope with the growing demand in the future. Supply of bamboo may be increased through large-scale commercial or industrial plantations to fulfil the gap between demand and supply. However, the main problem for commercial plantation of bamboo species in Malaysia is the inadequate supply of quality planting materials since most of the commercially important bamboo species do not produce or produce few seeds after long intervals. The current study was therefore, designed to investigate the mass propagation potential of *D. asper* through branch cutting using an easy, inexpensive and efficient method. Primary or secondary branches consisting of three to four nodes along with the swollen base were planted into plastic buckets filled with coarse sand in partial shade under nursery condition. Before planting the cuttings, bases were treated with 0, 0.2, 0.4 or 0.8% indole-3-butyric acid (exogenous IBA) solution for 5 min. The species was found to develop root, shoot and rhizome even without any rooting hormone. However, rooting ability, shoot number and length and survival percentage were significantly enhanced when cuttings were treated with IBA. Findings of the present study are expected to have significant impact on vegetative propagation of this thick-walled bamboo species.

Keywords: Clonal propagation, growth performance, IBA concentration, rooting ability

INTRODUCTION

There are 70 species of bamboo (subfamily Bambusoideae, family Poaceae) in Malaysia (50 in Peninsular Malaysia, 30 in Sabah and 20 in Sarawak) (Wong 1989). Bamboo is a multipurpose plant and is used by millions of people living in and around South-East Asia for food, fodder, housing, clothing, medicine, recreation, raw materials for industries (pulp, paper, cloth, wine), furniture, construction, etc. Due to its versatile uses, bamboo is considered as the second most important non-timber forest product in Malaysia and is a good alternative to timber in producing high value-added goods (Mohamed et al. 2009) and emergency rural housing after natural calamities especially floods. Bamboo is a good carbon sequestrating agent that can grow with minimal water and contributes to the conservation of soil and water.

The declination of timber production from the natural forests due to population growth and market demand is affecting the wood-based industries in Malaysia. As a fast growing plant, bamboo is an important alternative to timber in ensuring adequate and reliable supply of raw materials with great potential in the future (Wahab et al. 2012). However, with the ever increasing population and improvement of living standards, booming tourism industries, and demand for paper and cloth manufacturing and cottage industries, the gap between demand and supply of bamboo is widening. Supply of bamboo can be increased through raising intensively managed high-density plantations in degraded forest and non-forest areas. Initiatives of large-scale commercial or industrial plantations may take the lead in bamboo production to fulfil the gap between demand and supply. However, the main constraint for commercial bamboo plantation in Malaysia is the supply of quality planting materials (Othman 2002) since most

of the commercially valuable bamboo species do not produce or produce few seeds after long intervals.

Of the 70 species of bamboo in Malaysia, 14 have been identified as commercially important (Mohamed et al. 2009) and are commonly utilised for food (edible shoot) and making chopsticks, poultry cases, vegetable boxes, poles, frame, furniture and crafts. *Dendrocalamus asper* is an important thick-walled bamboo species in Malaysia. Also known as rough bamboo, black bamboo, giant or sweet bamboo, *D. asper* attains a height of 20–30 m with 8–20 cm diameter and 20–45 cm long internodes, and has relatively thick walls (Figure 1).

Flowering cycle and seed-setting of bamboo are irregular due to its monocarpic flowering which occurs once in about every 25–60 years (Nadgir et al. 1984). Since bamboo seeds are limited and short-lived, bamboo species are mainly propagated vegetatively using rhizome cuttings and, in some cases, air layering. Vegetative propagation by rhizome or offset cuttings is an age-old practice but the method is not suitable for raising large-scale plantations due to limited supply of rhizomes and offsets along with bulkiness and difficulties in extraction and transportation (Pattanaik et al. 2004). The plantlets also grow slowly in plantations (Hassan 1980). Pre-rooted branch cuttings can only be made during rainy season and only a few branches develop roots at their bases while attached to the mother culms, making the method inapplicable for year-round large-scale commercial plantation programmes.

Branch-cutting technique of bamboo can overcome most of these obstacles as it is inexpensive, produces large number of planting materials with high survival potential in a short period of time and reduces the labour and transportation costs (Hossain et al. 2005, 2006, Hossain & Arefin 2012). Usually every node of the segmented axis of a bamboo bears a bud or a branch, and branches in turn have buds in their

Figure 1 (a) Mature culms and (b) branching pattern of *Dendrocalamus asper* in the clump

axils. Several studies on vegetative propagation have aimed at transforming these buds into planting materials. Cuttings start to develop active buds within 1 week and plentiful roots within 4–6 weeks, depending on the species, cutting types and season (Hossain et al. 2005, 2006). The method of adventitious rooting in branch cuttings has been successfully adopted for propagating many species of bamboo.

Some bamboo species have been successfully propagated experimentally through tissue culture (e.g. Banerjee et al. 2011, Shroti et al. 2012). Although a large number of reports on in-vitro and/or micropropagation techniques of bamboo had been published, most of these studies were for experimental purposes and had not been tested in the field. This indicates the requirement of research in vegetative propagation of bamboo in Malaysia and in the world as well. However, in-vitro and micropropagation techniques involve expensive set up of laboratory and costly operational procedures which make them beyond the reach of rural people. These methods are also not useful in the forest or rural areas without uninterrupted electricity. Collection and utilisation of explants from selected plus tree far from the laboratory make the procedure difficult. Propagation through rooting of branch cuttings is therefore a better option in these situations as enormous propagules can be obtained from a single clump (Pattanaik et al. 2004, Hossain et al. 2005, 2006, Islam et al. 2011). The branch cuttings (macropropagation) may also be used as an intermediate step between mature bamboo clump in remote areas and the micropropagation in the laboratory that provides juvenile viable explants for tissue culture programmes. The present research project was designed to develop an easy, inexpensive and efficient regeneration method for the commercially important thick bamboo species *D. asper* through branch cutting with or without rooting hormones.

MATERIALS AND METHODS

The study was conducted for a period of 2 years from January 2014 till December 2015 in the nursery of the Faculty of Forestry, Universiti Putra Malaysia (2° 59' N, 101° 42' E), Serdang, Selangor, Malaysia. The study area experiences typically tropical hot humid climate with 12-hour day and night cycle.

Selection of clump and collection of branch for rooting

Extensive field visits were made to explore, identify and select healthy vigorous clumps for branch cuttings. The superior clump was selected at the Forest Research Institute Malaysia campus based on certain characteristics, namely, (1) the clumps were mature enough, (2) growth potential and (3) resistance to diseases and pests. Branches were collected from less than 2-year-old pre-selected culms for making cuttings (Banik 2000) using handsaw and secateurs.

Preparation of cuttings and hormone treatment

Primary or secondary branches with swollen bases consisting of three to four nodes were used for cuttings. In case of shorter internodes, four to five node segments were made from the base since more nodes in the cuttings increases the possibility of rooting (Banik 2000, Hossain et al. 2006). Average length (79.71 to 85.62 cm) and diameter (17.04 to 19.3 mm) of the cuttings were kept indifferent to avoid non-treatment variations. After segmentation, cuttings were kept in water to avoid loss of moisture from the cut ends. Cutting base were immersed briefly in fungicide (Diathane® M-45 at 2 g L^{-1} water) to avoid fungal infection. Effects of rooting hormones on rooting ability of cuttings were studied by treating the cuttings with 0, 0.2, 0.4 and 0.8% (0, 2000, 4000 and 8000 ppm respectively) rooting hormone (indole-3-butyric acid (IBA) solution) for 5 min.

Rooting media and experimental design

The cuttings were planted in plastic buckets filled with cleaned coarse sand mixed with fine gravel for rooting. Thirty cuttings in three replications (10 cuttings in each bucket served as one replication) were planted for each treatment (0, 0.2, 0.4 and 0.8% IBA solution). The buckets containing cuttings were then placed in partial shade, allowing 35% sunlight. Low light intensity prevented drying up and enhanced rooting ability of *B. vulgaris* cuttings (Hossain et al. 2005). Several holes were made at the bottom of the bucket prior to planting of cuttings for drainage of excess water. A randomised complete

block design was adopted to explore the effects of different treatments on rooting ability of cuttings. The cuttings were watered every 3 hours in the first week and after that, thrice a day until the rooted cuttings were transferred into polybags.

Acclimatisation and transferring of rooted cuttings

Dendrocalamus asper branch cuttings started to produce roots and buds within 7 days and well developed roots and shoots were noticed within 4 to 6 weeks. After 6 weeks of setting the experiment, rooted cuttings were transferred into polybags filled with soil mixture and kept in shade for 1 week and in the nursery bed for several months to assess steckling capacity and initial growth performance in the nursery condition. Rooting percentage, root number and length, shoot number and length, and length and diameter of cuttings were recorded during transplanting the cuttings into polybags 6 weeks after setting them in the rooting medium. Survival percentage, number of shoot developed and height of all coppice of the cuttings were determined 6 months after transplanting. The propagules were outplanted in the experimental plots for assessing the growth performance and other properties of the bamboo.

Statistical analysis

Quantitative and qualitative parameters, i.e. rooting percentage, root length, root number, shoot length and shoot number, survival percentage, initial growth rate and number of coppice produced per cutting were monitored, analysed and expressed as means and standard errors. All data were analysed using IBM SPSS version 22 (2014) after conducting the suitable transformation. Possible treatment variations were determined by analysis of variance and Duncan's multiple range tests.

RESULTS AND DISCUSSION

Rooting percentage

Rooting percentage of *D. asper* branch cuttings was significantly affected by the applied IBA rooting hormone (Figure 2). The highest

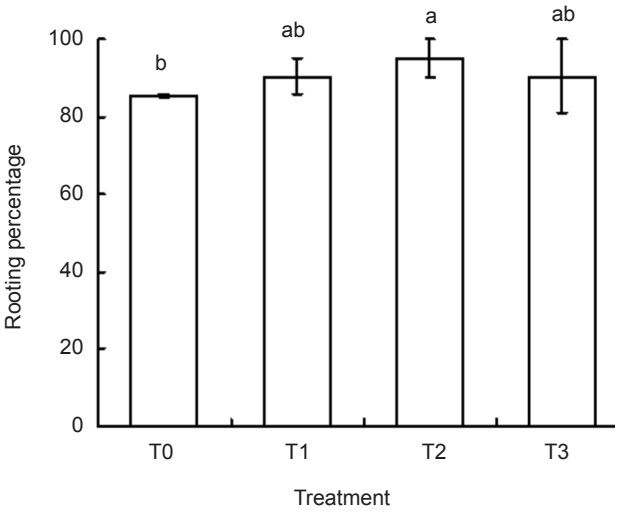

Figure 2 Rooting ability of *Dendrocalamus asper* branch cuttings under different concentrations of IBA solution; T0, T1, T2, T3 = 0, 0.2, 0.4 and 0.8% IBA respectively

rooting percentage (95.2%) was observed in the cuttings treated with 0.4% IBA solution followed by 0.2 and 0.8% IBA and lowest was in control cuttings for the species. IBA solution significantly enhanced rooting percentage of *B. vulgaris* branch cuttings (Hossain et al. 2006, Sharma 1980). The maximum rooting percentage of the *D. asper* branch cuttings in this study was much higher than in *B. vulgaris* (84%, Hossain et al. 2005), *B. vulgaris* var. *striata* (63%, Hossain et al. 2006) and *Guadua angustifolia* leafy cuttings (85%, Somashekar et al. 2004).

Rooting ability of branch cuttings depends largely on many internal and external factors including inherent capacity of the plant to form rooting primodia and roots in the cuttings. Some species readily form roots in cuttings while others may be very difficult to root. For instance, *Bambusa tulda*, *Dendrocalamus longispathus*, *Melocanna baccifera*, *Neohouzeaua dullooa* (syn. *Schizostachyum dullooa*) and *Oxytenanthera nigrociliata* (syn. *Gigantochloa rostrata*) showed very poor or no rooting in the branch cuttings (Hassan 1980). *Dendrocalamus asper* could thus be considered as ready to root species since most of the cuttings produced roots even without application of any rooting hormone.

Root and shoot number of cuttings

Number of roots developed per cutting varied from 53.7 to 121.7 with maximum number in the

treatment using 0.8% IBA solution followed by the 107.7 in 0.4% IBA and lowest (53.7) was in the control (Figure 3a). Number of shoots produced per cutting ranged between 11.6 and 15.9 but they were not significantly different (Figure 3a). The highest number of shoots produced per cutting was in the control and lowest was in 0.2% IBA treatment. Similar results were reported by Hossain et al. (2005) who reported the highest number of roots was produced in *B. vulgaris* branch cuttings treated with 0.2% IBA solution. Maximum numbers of roots for nodal leafy and tip cuttings of *B. vulgaris* were 9.8 and 8.3 after treatment with 0.8 and 0.4% IBA solution respectively, while the lowest was in the control (Islam et al. 2011). Branch cuttings of *B. vulgaris* var. *striata* were affected by IBA growth hormone but not by naphthaleneacetic acid (Hossain et al. 2006).

Root and shoot length of the cuttings

The length of root produced in cuttings was also significantly affected by exogenous application of various concentrations of IBA. The total length of roots in each *D. asper* branch cutting varied from 389.6 to 1115.2 cm, the longest being in the 0.8% IBA treatment followed by 0.4% IBA (979.9 cm) and lowest in the control (Figure 3b). Although shoot length did not vary significantly between treatments, maximum shoot length (262.4 cm) was observed in the cuttings treated with 0.4% IBA solution, followed by 203.6 cm in control and lowest was in 0.2% IBA treatment. However, there is no relevant report to compare or explain the variation in shoot length of the cuttings under different treatments. Cuttings with low concentration (0.2%) or without IBA treatment did not get sufficient amount of rooting hormone

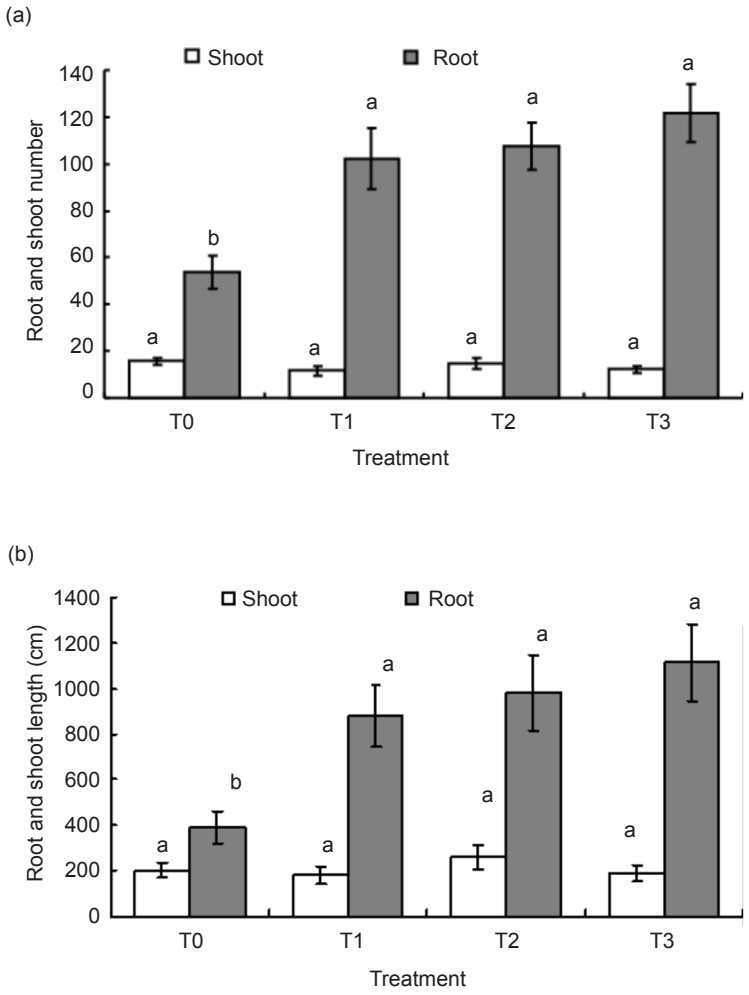

Figure 3 (a) Number of roots and shoots and (b) total length of roots and shoots of *Dendrocalamus asper* treated using different concentrations of IBA solution; T0, T1, T2, T3 = 0, 0.2, 0.4 and 0.8% IBA solution respectively

to develop roots or shoots in the similar fashion as cuttings treated with 0.4 and 0.8% IBA solutions. On the other hand, cuttings treated with high concentration (0.8%) of IBA produced more roots than shoots. This was because rooting hormone influenced the cuttings by allocating more energy for root than shoot development.

Survival percentages and initial growth performance

Survival percentage of *D. asper* rooted cuttings varied from 66.7 to 86.6% 6 months after transferring them into the polybags, with maximum survival in cuttings rooted with 0.4% IBA solution followed by 0.2% and lowest, control (Figure 4a). Almost every rooted cutting formed rhizome and produced culm (coppice) within 2 months of transferring into polybags and they were ready for outplanting 6 months after transplanting (Figure 4b). Culm height did not differ significantly between treatments after 6 months. Culm height varied from 209.3 to 250.6 cm across treatments. Significant effects of the application of rooting hormone (during the rooting period) on survival of rooted cuttings have been reported by Pattanaik et al. (2004), Hossain et al. (2005) and Islam et al. (2011). This might be due to early root formation and greater number of roots produced due to the application of rooting hormone compared with control.

CONCLUSIONS

Branch cutting, as a propagation method has been described for various important bamboo species. Development of planting materials from bamboo branch cuttings involved rooting and the formation of rhizome. The present study investigated the rooting ability of a thick-walled important bamboo species *D. asper* treated with four levels of IBA rooting hormone in partial shade under nursery condition. IBA significantly enhanced rooting ability of cuttings in terms of rooting percentage, root number and length, shoot number and length, survival percentage and initial growth performance. The highest rooting percentage, shoot number and length, survival percentage and initial growth performance of the rooted cuttings were observed in the cuttings treated with 0.4% IBA solution but the number of root

Figure 4 (a) Survival percentage and initial growth performance of coppices (culms) and (b) culms ready for outplanting 6 months after transplanting; T0, T1, T2, T3 = 0, 0.2, 0.4 and 0.8% IBA solution respectively

and root length was maximum with 0.8% IBA solution. Almost all rooted cutting formed rhizome at the base from where new culms developed. Although field performance of planting stock produced in this study was not assessed, cuttings treated with 0.4% IBA solution for the rooting of *D. asper* in partial shade might be recommended for mass clonal propagation and large-scale plantation programmes.

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REFERENCES

Banerjee M, Gantait S & Pramanik BR. 2011. A two step method for accelerated mass propagation of *Dendrocalamus asper* and their evaluation in field. *Physiology* and *Molecular Biology* of *Plant* 17: 387–393. doi:10.1007/s12298-011-0088-0.

Banik RL. 2000. *Silviculture and Field Guide to Priority Bamboos of Bangladesh and South Asia*. Bangladesh Forest Research Institute, Chittagong.

Hassan SM. 1980. Studies on the structures and growth of bamboo buds in the light of their probable use in tissue culture. *Bano Bigyan Patrika* 9: 7–16.

Hossain MA, Islam MS & Hossain MM. 2005. Effect of light intensity and rooting hormone on propagation of *Bambusa vulgaris* Schrad ex Wendl. by branch cutting. *Journal of Bamboo and Rattan* 3: 231–241.

Hossain MA, Jewel MEU, Sen M & Serajuddoula M. 2006. Rooting ability of *Bambusa vulgaris* var. *striata* branch cutting as influenced by cutting types and rooting hormones. *Journal of Bamboo and Rattan* 5: 117–126.

Hossain MA & Arefin G. 2012. Mass clonal propagation of *Bambusa balcooa* and *B. nutans* by branch cutting in non-mist propagation system. *International Journal of Forest Usufructs Management* 13: 13–25.

Islam MS, Bhuiyan MK, Hossain MM & Hossain MA. 2011. Clonal propagation of *Bambusa vulgaris* by leafy branch cuttings. *Journal of Forestry Research* 22: 387–392.

Mohamed AH, Kadir WRWA, Halis R & Abdullah NMH. 2009. Early performance trial of four Malaysian commercial bamboos in southern Peninsular Malaysia. *Borneo Science* 25: 81–85

Nadgir AL, Phadke CH, Gupta PK, Parshrami VA, Nair S & Mascarenhas AF. 1984. Rapid multiplication of bamboo by tissue culture. *Silvae Genetica* 33: 219–223.

Othman AR. 2002. A note on culm yield and above-ground biomass of *Gigantochloa levis* raised by tissue culture and branch cuttings planting materials. *Journal of Bamboo and Rattan* 1: 193–198.

Pattanaik S, Das P, Borah E, Kaur H & Borah K. 2004. Vegetative multiplication of *Bambusa balcooa* Roxb. using branch cuttings. *Journal of Bamboo and Rattan* 3: 301–412.

Sharma YM. 1980. Bamboos in the Asia-Pacific region. Pp 99–120 in Lessard G & Chouinard A (eds) *Bamboo Research in Asia*. IDRC and IUFRO, Ottawa.

Shroti RK, Upadhyay R, Niratkar C & Singh M. 2012. Micropropagation of *Dendrocalamus asper* through internodal segment. *Bulletin of Environment, Pharmacology and Life Sciences* 1: 58–60.

Somashekar PV, Lakshmianth KK, Rathore TS & Reddy KS. 2004. Macro propagation of *Guadua angustifolia* Kunthan exotic and fast growing bamboo species. *Indian Forester* 130: 655–662.

Wahab R, Mustafa MT, Salam MA, Tabert TA, Sulaiman O & Sudin M. 2012. Potential and structural variation of some selected cultivated bamboo species in Peninsular Malaysia. *International Journal of Biology* 4: 10–116.

Wong KM. 1989. Current and potential use of bamboo in Peninsular Malaysia. *Journal of American Bamboo Society* 7: l–15.