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Vegetative multiplication of *Bambusa balcooa* Roxb. using branch cuttings

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Abstract—Two noded branch cuttings of *Bambusa balcooa* Roxb., with rhizomatous swelling, treated with 200 ppm indole-3-butyric acid, gave 66.7% success in rooting and rhizome formation. 100% field survivals were noticed 2 years after field planting. However, the culms produced were small. Intensive management practices like fertilization, irrigation and regular soil working shortened the establishment period. The possibility of combining macroproliferation with branch cutting technique needs to be explored for fast multiplication of the species.

Key words: Branch cutting; *Bambusa balcooa*; rhizomatous swelling; vegetative multiplication.

INTRODUCTION

With the ever-increasing population and improvement in standards of living, the gap between demand and supply of bamboos for pulping and other uses is widening. Natural bamboo forests are unable to supply these needs because of low productivity and their diminishing population. Supply may be raised through raising intensively managed high-density plantations and by adopting unconventional methods of propagation like rooting of branch cuttings. According to one estimate the current demand for bamboo stocks in India is 90–120 million seedlings per annum, and this is expected to increase up to 300 million [1].

Propagation using seeds poses problems due to low viability, poor storage characteristics and microbial infestation. In addition, seed availability is uncertain due to long flowering cycles. The amount of seed collected from sporadic flowering is also limited. Vegetative methods are, therefore, the most usual way of propagation [2]. The most prevalent methods of vegetative propagation are through clump divisions, and use of rhizomes and offsets. All these methods give a reasonable success rate. But propagation through these methods is limited,

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Figure 1. View of the *Bambusa balcooa* plantation raised from branch cuttings.

because of bulkiness, difficulty in extraction, transportation and low availability per clump. Methods adopted for large-scale multiplication are macroproliferation, culm cuttings and branch cuttings. Multiplication through macroproliferation depends on availability of seeds. Hence, propagation through culm and branch cuttings is the most promising. Branch cuttings, because of their easy availability and cheapness, could be the future propagating material [3].

Bambusa balcooa, locally known as Bhaluka bans in Assam, is also found in Arunachal Pradesh, Nagaland, Meghalaya, Tripura, West Bengal, Bihar, extending to eastern part of Uttar Pradesh [4]. It is extensively cultivated in the homesteads of Assam. It is a tall bamboo with dull greyish green culms, which reach 16–23 m high and 8–15 cm in diameter (Fig. 1). The internodes are 20–45 cm long and are thick walled (Fig. 2). It shows a strong branching habit (Fig. 3). Branches from the lower

Figure 2. Close-up of a *Bambusa balcooa* clump showing old and new culms.

nodes are leafless and hard. *B. balcooa* is probably the best and strongest species for building purposes [5]. It is greatly valued in Bengal and the Brahmaputra valley of Assam. Other uses include paper pulp, agarbatti sticks in Tripura and the wood chip industry.

Previous work on branch cuttings of this species has yielded low success rates, of 18.5 [6] and 40% [3]. The present experiments reported below were carried out at the Rain Forest Research Institute, Jorhat and aimed at standardizing the propagule size, portion of branch and hormone concentrations for mass multiplication.

MATERIALS AND METHODS

Two experiments were done, one in a completely randomised design involving 5 cutting sizes, and the other in a factorial completely randomised design involving 4 branch portions and 10 hormone concentrations, one after the other. Branches were collected in the month of May 1999, from 3–4-year-old culms belonging to healthy mother clumps taking care to collect rhizomatous swellings in the branches so collected.

In the first experiment the branches were cut into one-noded (T_1), two-noded (T_2), three-noded (T_3), four-noded (T_4) and five-noded (T_5) cuttings. Each of the cuttings

Figure 3. Close-up of a *Bambusa balcooa* culm showing nodes, internodes and branches.

had the basal rhizomatous swelling. The top-cut end of the cuttings was sealed using wax to prevent desiccation and the bottom end was treated prophylactically with 0.01% Bavistin (i.e., Carbendazim, a broad-spectrum systemic fungicide) solution.

Nine cuttings were planted vertically in polybags, keeping the rhizomatous swelling and one node in the rooting media consisting of equal parts of soil, sand and farm yard manure, for each of the treatments.

In the second experiment the branches were cut into two noded cuttings starting from the base of the branch in such a way that the first cutting had the rhizomatous swelling (P_1, cutting with rhizomatous swelling and first two nodes; P_2, cutting with the third and fourth node; P_3, cutting with the fifth and sixth node; P_4, cutting with the seventh and eighth node). Cuttings were treated with different concentrations of three root-inducing substances, *viz*., indole-3-butyric acid (IBA), α-naphthalene acetic acid (NAA) and boric acid (BA) for 24 h (H_0, control; H_1, IBA (50 ppm), H_2, IBA (100 ppm); H_3, IBA (200 ppm); H_4, NAA (50 ppm); H_5, NAA (100 ppm); H_6, NAA (200 ppm); H_7, BA (50 ppm); H_8, BA (100 ppm), H_9, BA (200 ppm)). Just before planting the top-cut end of the cuttings were sealed using wax to prevent desiccation and the lower end prophylactically treated with 0.01% Bavistin solution. Nine cuttings were planted vertically in polybags, keeping the rhizomatous swelling and one node in the rooting media consisting of equal parts of soil, sand and farm yard manure, for each of the treatment combinations.

The polybags were kept under partial shade (75% shade provided by agro shade nets) and irrigated daily during the first two months. Afterwards, the polybags were exposed to full sun light and the frequency of irrigation reduced to once every two days. Survival per cent, number of roots, maximum root length, number of shoots, shoot height and collar diameter were recorded during December 1999, seven months after planting of the cuttings in polybags.

The rooted and rhizomed cuttings were planted out in June 2000, with the onset of rainy season. Their survival percent and other growth parameters were recorded during June 2002, two years after out planting.

RESULTS

In the first experiment maximum rooting (33.4%) and rhizome formation was noticed in two noded cuttings. In this experiment, even though the number of cuttings survived was more the percentage of rooting and rhizome formation was low (Table 1). None of the four noded and five noded cuttings survived. The optimum size seems to be a cutting with two nodes and rhizomatous swelling. The bud present in the above ground node developed into sprouts 10–15 days after planting. Roots emerged from the existing root primordia on the rhizomatous swelling during July 1999, 2–3 months after planting. Finally, after 4–6 months, new shoots emerged from the rhizomatous swelling (Fig. 4). Cuttings that did not develop roots remained green for some time but then perished. Some of the cuttings developed roots but no rhizomes and shoot formation was noticed even after seven months.

In the second experiment, significant differences were observed among the four levels of the first factor (branch portion) for all the observed parameters, *viz*.,

Table 1.
Survival, rooting and rhizoming percentage

Treatment	Survival (%)	Cuttings rooted and rhizomed (%)
T_1 One-noded cutting	55.6	11.1
T_2 Two-noded cutting	77.8	33.4
T_3 Three-noded cutting	55.6	22.2
T_4 Four-noded cutting	—	—
T_5 Five-noded cutting	—	—

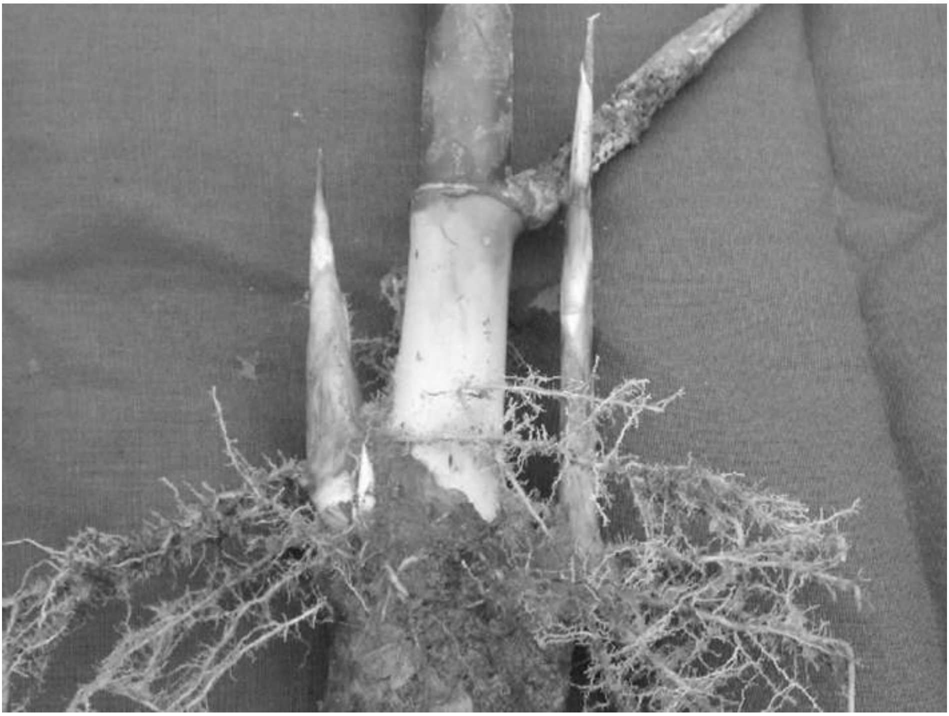

Figure 4. A rooted and rhizomed *Bambusa balcooa* branch cutting.

number of roots, maximum root length, number of shoots, shoot height and collar diameter (Table 2). Similarly, significant differences were observed among the ten levels of the second factor (hormone) for collar diameter, number of roots and maximum root length.

Cuttings with rhizomatous swelling and two nodes (P_1) treated with 200 ppm IBA (H_3) gave the highest per cent (66.7%) rooting and rhizome formation as compared to 33.3% in the control (Table 3). Cuttings treated with IBA induced better rooting percent as compared to NAA and BA. Further, even though cent percent survival was noticed in control, only 33.3% cuttings went on to produce roots and rhizome. None of the cuttings lacking a rhizomatous swelling survived: they remained green for 2–5 months and then perished.

Table 2.
Mean table showing the effect of hormone concentration and cutting position on different parameters

Shoot height (cm)		Collar diameter (mm)		Number of shoots		Number of roots		Root length (cm)	
Hormone concentration	Cutting position	Hormone concentration	Cutting position	Hormone concentration	Cutting position	Hormone concentration	Cutting position	Hormone concentration	Cutting position
H_0 0.584 (12.130)	P_1 0.943 (32.580	H_0 0.424 (1.333)	P_1 0.585 (3.260)	H_0 0.825 (0.250)	P_1 0.965 (0.521)	H_0 0.826 (3.75)	P_1 0.966 (12.666)	H_0 0.459 (2.917)	P_1 0.725 (9.344)
H_1 0.535 (14.194)	P_2 0.301 (0)	H_1 0.406 (1.333)	P_2 0.301 (0)	H_1 0.778 (0.138)	P_2 0.707 (0)	H_1 0.779 (4.333)	P_2 0.707 (0)	H_1 0.460 (3.805)	P_2 0.301 (0)
H_2 0.455 (7.805)	P_3 0.301 (0)	H_2 0.375 (0.833)	P_3 0.301 (0)	H_2 0.764 (0.111)	P_3 0.707 (0)	H_2 0.765 (3.166)	P_3 0.707 (0)	H_2 0.392 (1.444)	P_3 0.301 (0)
H_3 0.559 (14.833)	P_4 0.301 (0)	H_3 0.419 (1.416)	P_4 0.301 (0)	H_3 0.803 (0.194)	P_4 0.707 (0)	H_3 0.803 (7.861)	P_4 0.707 (0)	H_3 0.531 (7.805)	P_4 0.301 (0)
H_4 0.435 (6.680)	— —	H_4 0.358 (0.680)	— —	H_4 0.750 (0.083)	— —	H_4 0.750 (2.083)	— —	H_4 0.368 (0.930)	— —
H_5 0.500 (8.805)	— —	H_5 0.394 (1.055)	— —	H_5 0.76 (0.111)	— —	H_5 0.760 (4.138)	— —	H_5 0.434 (2.5)	— —
H_6 0.395 (5.555)	— —	H_6 0.334 (0.333)	— —	H_6 0.798 (0.194)	— —	H_6 0.799 (1.916)	— —	H_6 0.360 (1.166)	— —
H_7 0.440 (7.722)	— —	H_7 0.356 (0.611)	— —	H_7 0.735 (0.055)	— —	H_7 0.736 (2.5)	— —	H_7 0.380 (0.986)	— —
H_8 0.365 (1.777)	— —	H_8 0.328 (0.277)	— —	H_8 0.75 (0.219)	— —	H_8 0.750 (0.75)	— —	H_8 0.352 (0.972)	— —
H_9 0. 344 (1.944)	— —	H_9 0.322 (0.277)	— —	H_9 0.75 (0.083)	— —	H_9 0.750 (1.166)	— —	H_9 0.334 (0.833)	— —
CD NS	CD 0.145^{**}	CD 0.074^{*}	CD 0.062^{**}	CD NS	CD 0.056^{**}	CD 0.556^{*}	CD 0.464^{**}	CD 0.114^{*}	CD 0.095^{**}

Values in parentheses represent original values. CD, critical difference; NS, not significant.
* Significant at 5% level of significance.
** Significant at 1% level of significance.

Table 3.
Survival, rooting and rhizoming percentage in two noded branch cuttings treated with different concentrations of three root promoting chemicals

Treatment	Survival (%)	Cuttings rooted and rhizomed (%)
P_1H_0 Control	100	33.3
P_1H_1 IBA (50 ppm)	77.8	55.6
P_1H_2 IBA (100 ppm)	100	44.4
P_1H_3 IBA (200 ppm)	100	66.7
P_1H_4 NAA (50 ppm)	88.9	33.3
P_1H_5 NAA (100 ppm)	88.9	55.6
P_1H_6 NAA (200 ppm)	66.7	22.2
P_1H_7 BA (50 ppm)	100	33.3
P_1H_8 BA (100 ppm)	88.9	22.2
P_1H_9 BA (200 ppm)	100	11.1

Table 4.
Field performances of plants raised from branch cuttings

Sl No.	Survival			Culm production/ clump (No.)			Culm height (m)			Culm girth (cm)		
	Number planted	Number survived	%	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
1	16	16	100	1	7	3.1	0.35	6.9	1.9	1.2	13.4	5.6

100% survival was observed 2 years after outplanting of the rooted cuttings. The number of culms produced varied from 1 to 7, with an average of 3.1. Two of the plants did not produce any culm. Growth stagnation was observed in those two plants. The culm height varied from 0.35 to 6.9 m with a mean of 1.9 m and the basal girth varied from 1.2 to 13.4 cm with a mean of 5.6 cm (Table 4).

DISCUSSION

Branch cuttings as a method of propagation has been studied in different countries of Asia for important local species [7]. Yellow bamboo was successfully raised through rooting of branch cuttings by the Mysore Paper Mill [8]. The development of planting material from branch cuttings is a two-stage operation. The first is the striking of roots and the other, the development of rhizome. Branch cuttings, 45–50 cm long with swollen basal nodes and 2–3 branch nodes, are morphologically and physiologically similar to offsets and can be made to function like an offset in suitable conditions [6]. The present results lend support these findings.

The success of cuttings with rhizomatous swelling may be attributed to the preformed root and rhizome primordia which when in soil develop into root and rhizome respectively. Subsequently the tip of the rhizome extends upward in the form of a shoot. However, the existence of these root and rhizome primordia does not ensure success in all bamboo species. Hasan in 1977 [6] reported very poor or no rooting in *Bambusa tulda*, *Dendrocalamus longispathus*, *Melocanna baccifera*, *Neohouzeaua dullooa* (syn. *Schizostachyum dullooa*) and *Oxytenanthera nigrociliata* (syn. *Gigantochloa rostrata*). Selection of branch cuttings that have spontaneous *in situ* root and rhizome tips at their base has been stressed by researchers [9, 10]. Artificial induction of *in situ* rooting and rhizoming has been reported in *Bambusa polymorpha, B. vulgaris* and *B. burmanica* [11]. The amount of food material (C/N ratio) stored in branches is another factor responsible for the success or failure in rooting and rhizome formation. The swelling at the base of the branches is an indication that relatively more food is stored here than in the branches themselves.

In contrast, the cuttings without the rhizomatous swelling used in the experiment lacked the root and rhizome primordia. The buds on these branch cuttings are genetically programmed to develop into secondary branches. Upon planting in the rooting medium the buds burst into small leafy shoots, which probably exhausts the food (low C/N ratio) in these cuttings. Lack of feeder roots fails to provide nutrition and moisture to the growing shoot and as a result it dies after a few days. The cuttings with rhizomatous swelling are clearly at an advantage from the point of view of preformed root and rhizome buds as well as having more food material.

Rooting and rhizome induction is a slow process in branch cuttings. Plants reach the plantable stage after a period of 7–12 months. In addition, the establishment period (time taken by plants developed from cuttings to produce culms equal in size to those of a mother clump) after the field planting is longer using branch cuttings than using the offset method of planting. This time may be reduced by adopting intensive cultural management. The possibility of combining macroproliferation with branch cutting technique is now being explored for mass multiplication of the species. This will help in producing more than one plant from each of the individual cuttings planted.

REFERENCES

1. V. V. Srinivasan, Supply and demand of planting materials, constraints to production of bamboo and rattan, *INBAR Technical Report* **5** (1994).
2. I. V. R. Rao, I. U. Rao and F. N. Roohi, Bamboo propagation through conventional and in-vitro techniques, in: *Rapid propagation of fast growing woody species*, F. W. G. Baker, (Ed.), pp. 41–56. CABI, Melksham (1992).
3. 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**, 98–103 (1983).
4. Anonymous, *The Wealth of India, Raw Materials, Vol. 2B*, 37 pp. CSIR, New Delhi (1988).
5. J. S. Gamble, *Bambuseae* of British India, *Annals of Royal Botanic Garden*, 133 pp. Government Stationary Press, Calcutta (1896).
6. S. M. Hasan, Studies on the vegetative propagation of bamboos, *Bano Biggyan Patrika* **6** (2), 64–71 (1977).

7. R. L. Banik, Review of conventional propagation research in bamboos and future strategy, constraints to production of bamboo and rattan, *INBAR Technical Report* **5**, 115–142 (1994).
8. G. N. Bulganawar and K. M. Satishchandra, Propagation of yellow bamboo, in: *Proceedings of the National Seminar on Bamboo*, 19–20 December 1992, pp. 12–13. Bamboo Society of India, Bangalore (1992).
9. F. A. McClure, *The bamboos: a fresh perspective*. Harvard University Press, Boston, MA (1967).
10. 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).
11. R. L. Banik, Macropropagation of bamboos by prerooted and prerhizomed branch cutting, *Bano Biggyan Patrika* **13**, 67–73 (1984).