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RESEARCH ARTICLE

Effect of type and position of branch cuttings on rooting and root morphology in *Bambusa vulgaris* Schrad. ex. J.C. Wendl

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Abstract: An investigation was carried out to determine the effect of type and position of branch cuttings on rooting behaviour and root morphology in *Bambusa vulgaris* Schard. ex.J.C Wendl. using different concentrations of Indole butyric acid (IBA) harmone Maximum rooting was observed in primary (base end) cuttings treated with 1000 ppm. The propagules from single node basal end cuttings exhibited significantly higher values for all the root and shoot parameters studied. The advantage of utilizing branch cuttings for propagation is its abundant availability and ease of handling.

Keywords: bamboo, quality, propagation, hormone, cuttings

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Introduction

Bamboo, the golden grass, once considered poor man's timber, has now become the wise man's timber. Bamboos are monocotyledonous perennial grasses and diverse group of plants in the grass family, Poaceae. India is the second largest producer of bamboos next to China. Because of its fast growing nature, easy establishment, greater adoptability and readily available market it is cultivated everywhere in India except Kashmir. Bamboo species are found in almost all the states of India from the tropical to the temperate regions and the alluvial plains to the high mountains. (Kaushal *et al*., 2011). According to the bamboo resources of the country prepared by the Forest Survey of India, the total bamboo bearing area of the country is estimated to be 15 million hectare (FSI, 2021). Madhya Pradesh has maximum bamboo bearing area of 1.84 m ha followed by Arunachal Pradesh (1.57 m ha), Maharashtra (1.37 m ha), and Odisha (1.12 m ha) (F.S.I 2021). Their versatile use (Banik *et al*., 1997) is due to their excellent splitting ability (Banik, 2002), tensile and compressive strength, and amenability of being harvested within five years after planting (Negi, 1996).

Production of quality planting material is one of the major objective of National Agroforestry policy, 2014. Only 10 percent of the available planting material is of superior quality. Hence there is dearth of quality planting material. *Bambusa vulgaris* does not produce viable seeds. However, during the past one and half centuries as many as 20 incidences of flowering were reported from 10 countries (Koshy and Harikumar, 2000). The lack of seed set is mainly

Fig. 1. Mother plants

attributed to high percentage of pollen sterility and non availability. (Banik, 1995; John and Nadgauda, 1997). Factors responsible for failure of seed set in *B. vulgaris* seem to be manifold. High rate of pollen sterility, absence of natural pollination and inhibition of pollen tubes in the stigmatic papillae act as cumulative factors for lack of seed set in the species. (Koshy and Jee, 2001). Moreover, the stigma in *B. vulgaris* is dry and no pollen was found on it under natural conditions. (Koshy and Harikumar, 2000). From this, it can be inferred that there are some physical barrier adversely affecting pollination in this species. Propagation of bamboo through seed faces serious setback due to its erratic flowering and non-flowering nature. More over seeding in bamboo is very irregular and unavailable for most of the species (Arya *et al*. 2002; Ntirugulirwa *et al*. 2012). Hence, there is need to mass produce seedlings vegetatively for establishment of plantations. Keeping this in view an investigation was carried out on production of quality planting material of *Bambusa vulgaris* through branch cuttings at experimental farm of ICAR Central Agro forestry Research Institute, Jhansi with the following objectives.

1. Effect of type of branch cuttings and type of planting on rooting behavior in *Bambusa vulgaris*.
2. Effect of different concentrations of IBA on sprouting and rooting potential.

Material and methods

The experiment was conducted at ICAR- Central Agroforestry Research Institute, Jhansi. Branch cuttings were sourced from existing *Bambusa vulgaris* plantation at the experimental farm. The new branch were examined morphologically to ascertain the existence of buds, which may grow and form plant. The cuttings were defoliated and the axillary buds were left intact. Approximately equal proportions of the internodes were left on both sides of cuttings. Cuttings were categorized in to thick (basal end) and thin (top end) types based on the position from the branch. Six types of cuttings were prepared: One-noded cutting basal end, (6.5 cm in length and 4 cm in diameter). One-noded cutting top end, (5.5 cm in length and 2.5 cm in diameter), Two-noded cutting basal end, (40 cm in length and 4 cm in diameter), Two-noded cutting top end, 38 cm in length and 3 cm in diameter, Three-noded cutting basal end, (60 cm in length and 4.5 cm in diameter) and Three-noded cutting top end, (58 cm in length and 3 cm in diameter). The cuttings prepared were buried vertically in the sand (fig. 1).

Fig. 2. Preparation of nursery bed

Fig. 3. Planting of cuttings

Fig 4. Rooted cuttings

Experimental details

Summary of the experiments is as under;
(a) Number of species : One
(b) Auxin treatments : One (IBA)
(c) Concentrations : Seven concentrations of 1000 ppm, 2000 ppm, 3000 ppm, 4000 ppm, 5000 ppm, 6000 ppm, 0ppm
(d) Replications : Three
(e) Ramets : 6 per replicate
(f) Designs : Completely Randomized Design (CRD)
(g) Planting season : Summer (April-may)
(h) Planting of cuttings : April
(i) Planting environment : Nursery beds
(j) Planting medium : Sand

Observations

The rooted branch cuttings were carefully uprooted from the rooting medium after one month and observations were made on rooting percentage, number of roots, root length, number of sprouts and sprout length (fig 4).

1. *Rooting percentage*

Profuse rooting occurs within 4 weeks of planting in nursery beds. A cutting is regarded to be rooted when it had at least one visible root. The rooting percentage was calculated as;

$$\text{Number of cuttings rooted} = \frac{\text{Sprouting}}{\text{Total no.of cuttings planted}} \text{ X } 100$$

2. *Sprouting percentage*

A cutting is said to be sprouted when it had at least one shoot greater than 1 cm. sprouting percentage was counted under each treatment and calculated as;

$$\text{Number of cuttings rooted} = \frac{\text{Sprouting}}{\text{Total no.of cuttings planted}} \text{ X } 100$$

3. *Study on root parameters using root image analyzer*

Plant roots are highly heterogeneous and hierarchical. Roots that differ in diameter and order also differ in morphology, anatomy, and physiology (Berhongaray *et al*., 2013). Classifying roots by diameter is the most common research method due to its easy application (Thomas.,*et al*., 1996; Wells *et al*., 2002; Wen *et al.,* 1999; Baddeley and Watson, 2005; Mei., *et al*., 2006; Wu., *et al*., 2014). The roots were washed, segregated into different size. Measurement of root morphological traits by root image analysis of washed roots were carried out. Further, samples were soaked overnight, poured into trays, and rubbed gently. Roots floating on top of the water were collected by pouring water over sieves with mess size ranging from 5 to 0.5 mm sieve. Roots < 2 mm in diameter were considered as fine roots. The separation of live and dead roots were difficult, thus root mass given in paper includes both dead and live roots. The cleaned roots were scanned using a flatbed scanner Biovis Root Analyser, Expression 12000 XL EPSON, Expert Vision using the Biovis PSM Root software and further the root images were analysed for determination of fine root length. Fine root length density was computed by dividing total root length per core by total volume of the core. Root morphological features (total root length, average root diameter, total surface area of roots, root volume, number of tips, forks, and crossings were determined for each sample.

Data Analysis

Data collected were statistically analyzed by employing analysis of variance (ANOVA). For comparison of different means of different treatment, the critical difference (CD) were calculated at $p < 0.05$ level.

Fig 7. Analyzing roots from root image analyzer

Results

Effect of different concentration of IBA on root parameters

A. *One nodal basal end cutting and top end cutting*

The maximum mean number of roots (23.67), root length (7.50 cm), rooting percent (89%) was found highest in IBA 1000 ppm compared to other treatments in top end cuttings. The lowest mean number of roots (1.67), rooting percent (22%) was found in control. Similar trend was noticed in two noded basal end cuttings, number of roots (8.00), rooting percent (40%). However, the maximum root length was observed in IBA 5000 ppm (6.10 cm).

B. *Two nodal basal end cutting and top end cutting*

The maximum number of roots were observed in IBA 5000 ppm (28.00) and the least was noticed in IBA 1000 ppm (7.00) (table 3). The highest root length was observed in IBA 1000 ppm (13.22 cm) followed by IBA 6000 ppm (12.83 cm). Maximum rooting was observed in IBA 1000 ppm (80%). The least was noticed in IBA 6000 (22 %). In top end cuttings, maximum number of roots were observed in IBA 2000 ppm (11.67) followed by IBA 4000 ppm (11.33). The least was noticed in IBA 1000 ppm (2.67). Maximum root length was observed in IBA 1000 ppm (13.94 cm). The least was noticed in IBA 6000 (7.80 cm). The highest rooting percentage was noticed in IBA 1000 ppm. (52.00 %) and IBA 2000 ppm (50.00%). The least was noticed in IBA 5000 (22 %).

C. *Three nodal basal end cutting and top end cutting*

Maximum number of roots were observed in IBA 6000 ppm (7.67) followed by IBA 5000 ppm (6.67) and IBA 2000 ppm (6.0). The least was noticed in control (1.67) roots. Maximum root length was observed in IBA 5000 ppm (10.57cm) followed by IBA 2000 ppm (8.37cm) and IBA 3000 ppm (7.83cm). The least was noticed in control (4.53 cm). Maximum rooting percentage was observed in IBA 1000 ppm (22.60%) followed by IBA 2000 ppm (20.59 %). The least was noticed in control (7.10%) respectively.

Maximum mean number of roots were observed in IBA 6000 ppm (8.33) followed by IBA 5000 ppm (6.67) and IBA 4000 ppm (5.00). The least was noticed in control (3.00). Maximum root length was observed in IBA 3000 ppm (10.57cm) followed control (10.57cm) and IBA 4000 ppm (9.67 cm). The least was noticed in IBA 6000 ppm (7.10 cm) and IBA 5000 ppm (7.30 cm) respectively. Maximum rooting was observed in IBA 1000 ppm (21.00 %) followed by IBA 3000 ppm (14.67%). The least was noticed in control (9 %).

Effect of different concentration of IBA on sprout parameters

A. *One nodal top end cutting and basal end cutting*

The highest number of sprouts were observed in IBA 1000 ppm (18.00) followed by IBA 5000 ppm (9.33) and IBA 2000 ppm (9.00). The least was noticed in IBA 6000 ppm (4.66). Maximum sprout length was observed in IBA 6000 ppm (6.88 cm) and the

Table 1. Effect of different concentration of IBA on number of roots, root length and rooting.

	1000	2000	3000	4000	5000	6000	Control	CD at 5%
Single noded top end cutting								
Mean number of roots	23.67	13.33	11.67	5.67	3.00	4.00	1.67	29.2
Mean root length (cm)	7.50	3.34	3.33	4.00	4.91	3.86	4.61	11.14
Mean Rooting %	89	78	67	45	33	33	22	140.11
Single noded basal end cutting								
Mean number of roots	8.00	3.67	3.00	2.33	1.33	1.33	1.00	9.07
Mean root length (cm)	3.55	3.88	3.87	4.88	6.10	4.13	4.37	10.62
Mean Rooting %	40.00	28.00	28.00	22.00	22.00	17.00	17.00	62.00
Two noded top end cuttings								
Mean Number of roots	7.00	18.67	22.33	19.00	28.00	14.00	9.00	47.69
Mean root length (cm)	13.22	7.14	7.97	7.22	6.39	12.83	7.8	128.95
Mean Rooting %	80	78	70	68	50	22	39	23.39
Two noded basal end cuttings								
Mean Number of roots	2.67	11.67	7.33	11.33	7.00	11.33	10.00	22.35
Mean root length (cm)	13.94	9.33	11.08	8.64	12.83	7.80	8.05	25.36
Mean Rooting %	52	50	39	44	22	44	44	93
Three noded top end cuttings								
Mean Number of roots	3.00	6.00	5.00	4.33	6.67	7.67	1.67	15.62
Mean root length (cm)	5.18	8.37	7.83	7.10	10.57	6.22	4.53	22.39
Mean Rooting %	22.60	20.59	17.01	14.71	11.01	8.95	7.10	13.94
Three noded basal end cuttings								
Mean Number of roots	3.33	4.0	3.67	5.00	6.67	8.33	3.00	15.19
Mean root length (cm)	7.92	7.47	10.57	9.67	7.30	7.10	10.57	24.6
Mean Rooting %	21.00	14.54	14.67	11.40	9.33	9.95	9.0	4.01

Table 2: Effect of different concentration of IBA on number of sprouts, sprout length and sprouting percent

	1000	2000	3000	4000	5000	6000	Control	CD at 5%
Single noded top end cutting								
Mean number of sprouts	18.00	9.00	7.33	8.33	9.33	4.66	5.66	4.21
Mean sprout length (cm)	6.05	6.02	6.22	5.17	6.08	6.88	5.75	4.79
Sprout percentage	100	100	100	94	100	61	89	220.22
Single noded basal end cutting								
Mean number of sprouts	8.00	7.00	7.67	4.00	4.67	4.00	1.33	13.96
Mean sprout length (cm)	6.14	5.49	5.58	5.08	6.02	5.58	5.55	13.34
Sprout percentage	78	100	78	55	50	22	22	154.77
Two noded top end cuttings								
Mean number of sprouts	9.67	12.00	9.67	8.67	9.00	7.00	9.67	23.44
Mean sprout length (cm)	4.86	5.11	5.19	5.44	5.19	5.47	5.08	12.26
Sprout percentage	88.89	94.44	61.11	50.00	38.89	72.22	88.89	175.2
Two noded basal end cuttings								
Mean number of sprouts	2.00	3.00	4.67	4.67	9.33	6.00	6.67	14.75
Mean sprout length (cm)	6.33	7.44	6.61	5.25	5.22	4.03	5.22	14.07
Sprout percentage	27.77	44.44	50.00	50.00	38.89	38.88	88.89	117.97
Three noded top end cuttings								
Mean number of sprouts	21.67	9.00	7.33	8.33	9.33	4.67	5.67	25.81
Mean sprout length (cm)	5.05	4.47	4.36	3.86	4.27	4.94	4.19	10.73
Sprout percentage	94.44	88.89	72.22	77.77	72.22	55.55	44.44	175.61
Three noded basal end cuttings								
Mean number of sprouts	13.00	5.33	5.33	3.00	3.67	3.33	1.67	14.53
Mean sprout length (cm)	3.47	4.72	4.86	4.39	6.77	4.61	4.14	13.06
Sprout percentage (%)	77.77	83.33	61.11	41.67	50.00	22.22	27.77	131.76

lowest was noticed in IBA 4000 ppm (5.17 cm) and control (5.75 cm) respectively. Maximum sprouting percentage was observed in IBA 1000 ppm (100 %) followed by IBA 2000 ppm (100 %) and IBA 3000 (100 %). The least was noticed in IBA 6000 (61.11%). In basal end cutting, maximum number of sprouts were observed in IBA 1000 ppm (8.00) followed by IBA 2000 ppm (7.00) and IBA 3000 ppm (7.67). The least was noticed in control (1.33). Maximum sprout length was observed in IBA 1000 ppm (6.14 cm) followed by IBA 5000 ppm (6.02 cm) and IBA 3000 ppm (5.58cm). The lowest was found in IBA 4000 ppm (5.08 cm). Maximum sprouting percentage was observed in IBA 2000 ppm (100 %) followed by IBA 1000 ppm (78 %) and IBA 3000 (78 %). The least was noticed in IBA 6000 (22 %) followed by untreated cuttings (22 %).

B. *Two nodal basal end cutting and top end cutting*

Maximum number of sprouts were observed in IBA 2000 ppm (12.00) followed by IBA 1000 ppm (9.67) and control (9.67). The least was noticed in IBA 6000 ppm (7.00). Maximum sprout length was observed in IBA 6000 ppm (5.47 cm) and the lowest was found in IBA 1000 ppm (4.86 cm) and control (5.08 cm) respectively. Maximum sprouting percentage was observed in IBA 2000 ppm (94.44 %) and the least was noticed in IBA 6000 (38.89 %).

In basal end cuttings, the maximum number of sprouts were observed in IBA 5000 ppm (9.33) followed by control (6.67) and IBA 6000 ppm (6.00). The least was noticed in IBA 1000 ppm (2.00) respectively. Maximum sprout length was observed in IBA 2000 ppm (7.44cm) followed by IBA 3000 ppm (6.61 cm) was observed in control (88.89 %). The least was noticed in IBA 1000 (27.77%) and IBA 6000 ppm (38.86%) and IBA 1000 ppm (6.33 cm). The lowest sprout length was found in IBA 6000 ppm (4.03 cm). The highest sprouting percentage was observed in control (88.89 %). The least was noticed in IBA 1000 (27.77%) and IBA 6000 ppm (38.86%).

C. *Three nodal top end cutting and basal end cutting*

Maximum number of sprouts were observed in IBA 1000 ppm (21.67) followed by IBA 5000 ppm (9.33) and IBA 2000 ppm (9.00). The least was noticed in IBA 6000 ppm (4.67). Maximum sprout length was observed in IBA 1000 ppm (5.05 cm) followed by IBA 6000 ppm (4.94 cm) and IBA 2000 ppm (4.77 cm). The lowest sprout length was found in IBA 4000 ppm (3.86 cm) and control (4.19 cm) respectively. Maximum sprouting was observed in IBA 1000 ppm (94.44%) followed by IBA 2000 ppm (88.89 %) and IBA 3000 (77.77 %). The least was noticed in control (44.44%).

D. *Effect of type of cuttings on various root parameters*

It is evident from the (table 4) and (figure 8) that, the average root length was found highest in two nodal cuttings (7.52 cm) followed by three node (4.84 cm) and single node cuttings (4.83) respectively. The number of root tips was found maximum in single node cutting (1151). The root segments was found highest in two node cuttings (1875) followed by single node (1403), the least was noticed in three nodal cuttings. The average diameter was found highest in three node cuttings (0.58) followed by single node and two node cuttings (0.51) and (0.39) mm respectively. The root fresh weight was found highest in two node cutting (1.31), followed by two node (0.95 gm). The maximum root dry weight was found in three node cuttings (0.79 gm) followed by single node (0.34) gm and two node (0.30 gm).

Discussion

In the present study, rooting percentage, number of roots, number of sprouts etc of branch cuttings of *B. vulgaris* varied significantly among the treatments. This finding is validated by several researchers who reported the influence of IBA on rooting and sprouting potential of bamboo branch cuttings. Hossain *et al.,* (2005) observed that rooting ability and growth performance of cuttings were affected significantly by IBA treatment. Auxins influences polysaccharide hydrolysis resulting in increased content of physiologically active sugar, which is required to provide energy for meristematic tissues and later for root primordia and formation of root (Nanda, 1974; Husen and Pal, 2007). The mean number of roots were found highest when cuttings were treated with lower concentrations of IBA. The two node cuttings produced more number of roots across the treatments when compared to control. This variation may be attributed to the genotypic characteristics, the endogenous food reserve, environmental factors and/or the interaction between them (Banik, 1984; Singh 2006). The results are further, in line with findings of (Castillo 1990) in *Bambusa vulgaris*, (Shanmughavel and Francis 1998) in *Bambusa bamboos*, Othman and Noor (1995) in *Bambusa vulgaris* var. striata. The number of roots were more in basal cutting as compared to top end cuttings, this may be attributed to higher cutting volume of primary cuttings which ultimately have more assimilates to be used for producing more number of roots and higher biomass in the cuttings. Uchimura (1977) found that, cuttings treated with 100 ppm IBA for 24 hours gave better rooting percentage and formation of longer roots in *B. vulgaris*. The rooting ability of the cuttings was significantly enhanced by the application of rooting hormone IBA (Islam *et al.,* 2011). Palijon (1983) reported that cuttings treated with rooting hormones were higher in shoot production and the shoots were taller and wider in diameter than those of untreated cuttings. Satyen chhetri and Hemant Kumar (2015) studied on the effect of planting position on rhizogenesis in buddha belly bamboo (*Bambusa ventricosa*) under nursery condition. The results revealed that the type and stem cutting had significant effect on the rhizogenesis and growth. Swapnendu Pattanaik (2004) studied on the vegetative multiplication of *Bambusa balcooa Roxb*. using branch cuttings, two noded branch cuttings with rhizomatous swelling, treated with 200 ppm indole-3-butyric acid, gave 66.7% success in rooting and rhizome formation. These findings are in line with Hossain *et al*., (2006) who reported that in *B. vulgaris* var. *striata* branch cuttings, average length of the longest roots was maximum for 0.2% IBA treatment followed by 0.4% IBA treatment and the lowest was in the control. Sajad Rizvi *et al*., 2011, reported that IBA showed more positive response on rooting as compared to IAA and NAA in *Bambusa vulgaris*. It was found from the study that, higher survival and number of shoots were observed in the transplanted cuttings treated with IBA that may be attributed to more number of roots and root length prior to transplanting in the polybags. The season also play an important role on adventitious rhizogensis. The cuttings which were treated with IBA and planted in the month of may give best results for rooting in *Bambusa nutans* (Singh, 2002).

Conclusion

In the present study the IBA at lower concentrations 1000 ppm gave best rooting and plant growth. The maximum mean number of roots, root length, rooting percentage was found highest in single node cuttings. Branch cuttings are available in plenty and can be easily used in multiplication of bamboo seedlings. In general, IBA was found to enhance the sprouting and rooting parameters in bamboo species. The maximum mean number of roots (23.67), root length (7.50 cm), rooting percent (89%) was highest in IBA 1000 ppm compared to other treatments in top end cuttings. The cuttings taken from the basal end across single node, two node and three node gave a higher rooting percentage. Hence it is recommended that the one node cuttings may be used to multiply large number of propagules followed by two node and three node. In bamboo spp vegetative propagation is the only means of production of propagules on large scale because the seed availability is uncertain due its irregular flowering habit and less viability. The present findings showed that Indole butyric acid (IBA) hormone contributes to effective propagation of *Bambusa vulgaris* branch cuttings and revealed that the plant requires IBA Harmone for fast growth.

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