Farmer-friendly technique for multiplication of bamboo (*Bambusa vulgaris*)

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***Bambusa vulgaris* was multiplied by burying whole culms during 2014 and 2015 at the Research Farm of ICAR-Central Agroforestry Research Institute, Jhansi. Two-year-old bamboo culms produced higher number (165) of shoots than 1-year (114) and 3-year-old culms (57). The culm planting method resulted in prolific rooting pattern during monsoon season, and on an average 5.7 rooted plants were obtained from every alternate node. Rooted sprouts were separated from each productive node along with fibrous roots attached to it and were planted in polythene bags as new plantlets. This method of planting was found impressive for developing live bamboo fence and producing a large number of plants from scarce planting material. This technique promises a large number of planting material and readily acceptable technology to the farmers.**

Keywords: Agroforestry, bamboo, carbon sequestration, farmer-friendly techniques.

BAMBOO is the green gold of the 21st century and also known as ‘poor man’s timber’. It has played a significant role since ancient times in the development of human society by providing fuel, food, fodder, shelter and fencing. Presently, it is used as a raw material for paper pulp, construction materials, panel products, etc. After the Kyoto Protocol, bamboo has been given more importance in land use such as afforestation/agroforestry for mitigation of climate change besides improving the livelihood of poor farmers. The fast growth of bamboo can be seen as an indication of greater ability to sequester CO_2. Carbon sequestration potential of bamboo ranges between 3.49 and 23.55 t ha^{-1} $year^{-1}$ depending upon the species and density[1]. In recent years, bamboo has attracted policy makers, farmers and corporate for its multiple uses.

India has rich bamboo diversity. *Dendrocalamus strictus*, commonly grows in Bundelkhand, Baghelkhand and Satpura ranges of Central India. *D. strictus* is clumsier with stunted growth and numerous rhizomes; hence separation of single culm from its clump is difficult. *Bambusa vulgaris* (hollow bamboo) is in great demand due to its multiple uses, fast growth, well-spaced rhyzomes and better market value. *B. vulgaris* can be multiplied by both branch[2] and culm cutting[3]. Micropropagation of bamboo in the central India is not popular because of harsh climatic conditions and poor economic conditions of the farmers.

To meet the large-scale demand of planting material of *B. vulgaris*, attempts were made to multiply the species by planting whole culms. It was also intended to develop robust and farmer-friendly techniques for live fence particularly along the farm bunds as protection to field crops from animals and water courses for nallah stabilization.

The present study was conducted at ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi during July and August 2014 and 2015. Soil of experimental site was red having 0.3% organic carbon, and pH 7.7. Five culms of each age group (1-, 2- and 3-year-old) were harvested from ground level from the established plantation at the ICAR-CAFRI farm. Branches of harvested culms were removed with a sharp secateur and mother culm was marked in three equal parts, viz. basal, middle and terminal, based upon the number of nodes. Table 1 shows characteristics of bamboo culm. Culms were buried horizontally (Figure 1) in soil and 3 cm thick mixture of sand + FYM + soil (1 : 1 : 1) was placed above them. Required moisture was maintained in the nursery through irrigation. For observations on root initiation, every time soil was removed on one side of each portion of culm in a length of 50 cm such that at least two nodes could be observed at two places. After two months of culm planting, the mother culm was carefully uprooted by digging on both sides. Observations on the number of roots and root length were recorded. Each shoot with independent root system was separated with a sharp knife and planted in black polythene bags filled with sand + soil + FYM (1 : 1 : 1) mixture. Data were statistically analysed (pooled analysis) using the *F*-test[4].

Shoot emergence was visible after 14 days of planting the culms (Table 2). Middle and terminal portion nodes produce early shoots compared to basal portion. Emergence of shoots was completed within 28 days after planting (DAP) in 1-year-old culms, and in 35 DAP in 2- and 3-year-old culms (Table 2 and Figure 2 *a*). This could be attributed to juvenile culms. Variation in days of

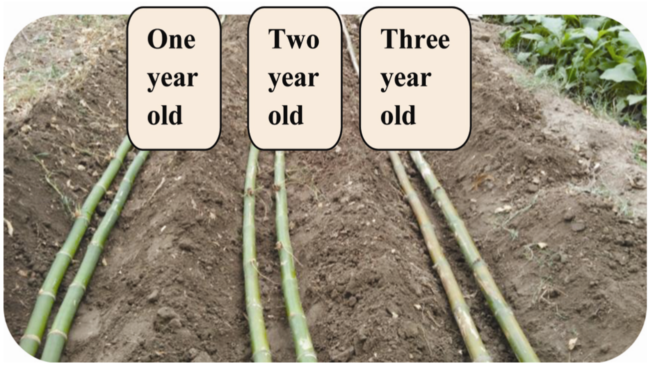

Figure 1. Burying of 1-, 2- and 3-year-old culms.

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Table 1. Characteristics of bamboo culm before planting (pooled data of two years)

Age and portion of culm	Length of culm (m)	Basal diameter (cm)	No. of nodes $culm^{-1}$	Average internodal length (cm)
One year				
Basal	3.74	10.4	9.83	38
Middle	3.12	10.2	9.83	32
Terminal	1.62	8.6	9.83	16
Two years				
Basal	4.05	9.6	11.3	36
Middle	3.55	9.5	11.3	31
Terminal	2.40	8.8	11.3	21
Three years				
Basal	2.56	11.2	9.66	27
Middle	2.18	10.9	9.66	23
Terminal	1.84	10.4	9.66	19

Table 2. Shoot and root emergence of planted culms (pooled data of two years)

Age and portion of culm	14 DAP		21 DAP		28 DAP		35 DAP		42 DAP		49 DAP	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
One year												
Basal	–	–	2	–	3.5	1	3.5	2	3.5	3.5	3.5	3.5
Middle	1	–	4	–	5.0	2	5.0	4	5.0	5.0	5.0	5.0
Terminal	1	–	4	–	7.0	2	7.0	4	7.0	7.0	7.0	7.0
Two years												
Basal	–	–	3	–	6.0	–	7.5	4	7.5	7.5	7.5	7.5
Middle	1	–	3	–	6.0	–	6.0	3	6.0	6.0	6.0	6.0
Terminal	1	–	4	–	8.0	–	9.5	6	9.5	9.5	9.5	9.5
Three years												
Basal	–	–	2	–	4.0	–	4.5	2	4.5	4.5	4.5	4.5
Middle	1	–	3	–	4.0	–	5.0	2	5.0	5.0	5.0	5.0
Terminal	2	–	3	–	5.0	–	5.0	2	5.0	5.0	5.0	5.0

DAP, Days after planting.

emergence of shoot in basal, middle and terminal portions of mother culm may be attributed to variation in invigoration of buds.

Root emergence was observed only after 28 DAP. Rooting in all productive nodes was observed only at 42 DAP. Numerous shoots were observed on each sprouting node which had its own root system from the base of the shoot (Figure 2 *b*). Similar to the trend observed in shoot emergence, highest number of roots was observed at 42 DAP in 2-year-old culm. Also, one or two basal nodes on the culm nearest to the ground had rooting all around it. However, such nodes did not set forth shoots (Figure 2 *c*). This may be attributed to dormant bud. It is common in bamboo-species that basal nodes do not set forth branches. No rooting was observed around the nodes in culms where shoots had emerged. This may be due to preformed root primordia at the basal node (near to ground), which is absent on other nodes. Seeding in bamboo species is erratic and takes place after long duration[2]. Hence bamboo multiplication is preferred through vegetative propagation.

The number of productive nodes varied with age and portion of culm (Table 3). In general, the number of productive nodes increased from basal to terminal end. This appears to be due to apical dominance resulting into higher growth activity at terminal end. At 42 DAP, it was observed that 2-year-old culms had 48.4% and 58.0% higher productive nodes than the 1- and 3-year-old culms respectively. Within a culm, terminal portion produced 38.70% and 34.30% higher productive nodes over basal and middle portions respectively. Terminal portion in 2-year-old culms recorded the highest number of productive nodes (84%). Close scrutiny of culms indicated that buds on the nodes were located opposite to each other. While burying bamboo in the nursery bed, the buds facing upwards produced shoots and roots, whereas those facing downwards failed to sprout (Figure 2 *b*). In the terminal portion, most of the buds were placed sideways because

Figure 2. ***a***, Emerged shoots at 28 days after planting (DAP) from culm of *Bambusa vulgaris*. ***b***, Emergence of shoots and roots at alternate nodes of culm. ***c***, Rooting all around node without shoot emergence on first basal node of culm. ***d***, Transplanted shoots of *B. vulgaris* in polythene bags.

Table 3. Shoot and root parameters in bamboo culm at 49 days after planting (pooled data of two years)

Age and portion of culm	Productive node/ portion of culm	No. of shoots/ productive node	Average length of longest root (cm)	No. of roots/node	No. of roots/shoot	Remarks
One year						
Basal	3.50 (35.6)	2.50	19.67	12.90	5.16	17% of nodes produced roots all around culm node, but no shoot
Middle	4.98 (50.7)	5.81	19.49	24.90	4.28	
Terminal	7.00 (71.2)	10.85	17.43	24.41	2.25	
Two years						
Basal	7.49 (66.3)	3.60	20.27	18.60	5.16	About 5%+ nodes at base produced roots all around culm, but no shoot
Middle	6.00 (53.1)	8.05	23.62	40.95	5.08	
Terminal	9.50 (84.0)	9.46	17.73	36.04	3.80	
Three years						
Basal	4.50 (46.6)	2.40	21.37	16.15	6.72	
Middle	4.97 (51.4)	2.66	17.15	38.60	5.48	
Terminal	5.00 (51.8)	6.66	15.77	24.40	3.66	
SEm ±	0.23	0.26	0.83	1.2	–	
LSD ($P = 0.05$)	0.71	0.80	2.51	3.6	–	

Percentage of productive nodes in each portion is given in parenthesis.

the terminal portion was thin, slightly twisted with little bends, and hence produced a number of shoots. Further, higher shoots per bud in the terminal portion may be attributed to active buds.

The number of shoots per node showed variability with respect to age of bamboo culm; however, the trend was observed to be erratic (Table 3). It was also observed that with an increase in the age of the culm, the number of shoots per node showed a decreasing trend. In general, the number of shoots per node increased from basal portion towards the terminal end. Maximum 10.85 shoots per node were recorded in the terminal portion (in 1-year-old culms), while minimum 2.40 shoots per node were recorded in the basal portion (3-year-old culms). More number of shoots per node is desirable from the viewpoint of producing a large number of plantlets from a

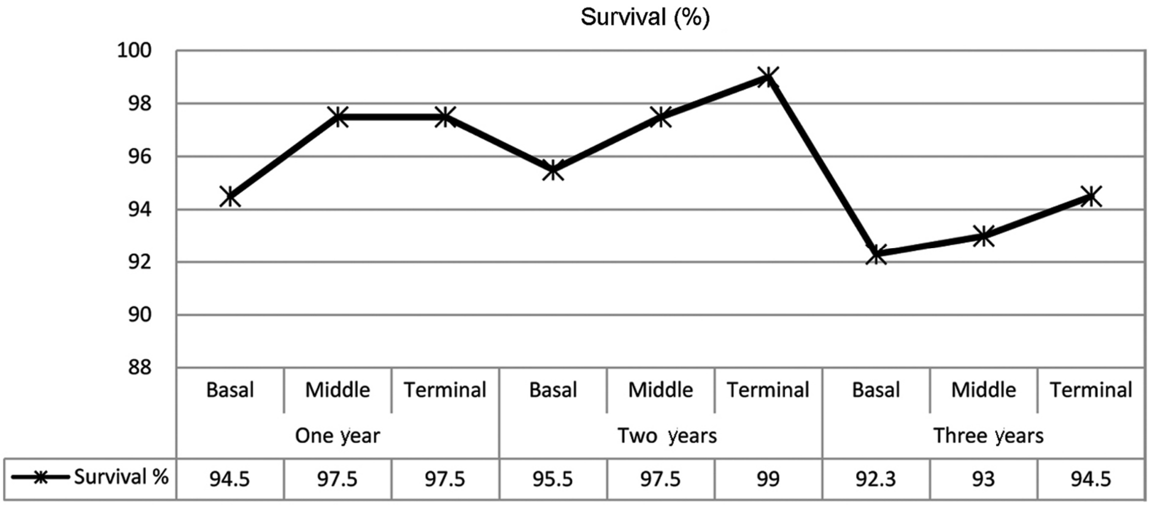

Figure 3. Survival (%) of shoots after being transplanted in polythene bag (pooled data of two years).

single culm. Every such shoot had an independent root system; hence on separation these behaved like separate plantlets.

Root observations were recorded after digging the culms, i.e. 2 months after planting (Table 3). It is apparent from the data that 2-year-old culms recorded highest root length (23.62 cm) in the middle nodes. Overall average root length was observed to be higher in 1-year-old (18.86 cm) and 2-year-old (20.54 cm) – culms compared to 3-year-old culms. This is in accordance with the number of days taken for shoot and root sprouting. Sujatha *et al.*[5] reported that bamboo has an extensive root system that ramifies horizontally and vertically and binds soil particles together.

The number of roots at each node varied in accordance with the number of shoots sprouted from each node and had a positive correlation with each other. Maximum number of roots per node (40.95) was recorded in the middle portion of 2-year-old culms followed by 3-year-old culms (38.60). Hossain[6] reported that in *B. vulgaris*, the number of roots in primary cutting was more compared to secondary cutting and attributed it to higher volume of stored food.

After 2 months of the study, each shoot was separated from the culm with its own root system and transplanted in polythene bags (Figure 2 *d*). Figure 3 shows that highest survival (97.5%) can be observed after 15 days of transplanting in 2-year-old culms followed by 1-year-old culms (93.0%). Shoots separated from the terminal portion showed the highest percentage of survival (99.0) followed by middle portion (96.0).

For large-scale multiplication of bamboo, 2-year-old culms may be harvested and buried 3 cm deep in the soil. The shoots emerging from productive nodes develop their own root system and can be separated as individual plantlets using a sharp knife. Therefore, the rate of multiplication can be increased rapidly by this method. After separation of plantlets, the mother culm can be used for commercial purposes as well.

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