Studies on Vegetative Propagation of Bambusa and Dendrocalamus Species by Culm Cuttings

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Abstract

Investigations have been undertaken to determine some of the factors that limit root production in *culm cuttings* of Bambusa *species. Whole culms* of Bambusa nutans gave *successfully rooted shoots in 8.8% of nodes and polythene tunnels did not improve the performance. The reasons for the high percentage of failure is explained. In comparison 70 – 84% cuttings* of Dendrocalamus hamiltonii *and* D. hookeri *produced rooted shoots. The reorientation of noded cuttings in* Bambusa nutans gave *an overall success rate of 59.5%. Competition from strong non-rooting shoots was shown to reduce rooting and a further simple refinement of the planting technique was shown to allow more shoots to root and at the same time reduce competition, giving* a *75% success rate. Further improvements are* suggested.

Introduction

Large stature bamboos of the genera *Bambusa* and *Dendrocalamus* are very important in the rural economy of Nepal. Being multi-purpose species they provide constructional materials, animal fodder, fuelwood, food, and woven products for agricultural and domestic purposes, as well as baskets for transport of most commodities beyond the roadheads in the hills. Planting large bamboos has in the past been severely restricted by lack of seed and lack of knowledge concerning improved vegetative propagation techniques, The traditional offset cutting has been used almost exclusively in Nepal until very recently.

Short culm cuttings offer many advantages over the traditional cutting. An average clump may provide only about five traditional cuttings each year without a severe reduction in clump vigour and productivity, while up to one or two hundred single-node culm cuttings can be taken without affecting clump productivity or disturbing the rhizome system. Traditional cuttings can weigh up to 40kg. each, making transport extremely difficult. Each culm cutting weighs about 1/2kg or less. Traditional cuttings retain certain advantages (Stapleton and Tamrakar, 1983). Nursery facilities are not required; survival is very good even under extremely arduous conditions; protection against grazing animals is much easier and establishment is quicker. The problems of communication and transport in the hills of Nepal and the simple nature of most forest nurseries impose severe restrictions upon propagation techniques.

Investigations as how to improve the success of culm cuttings in Nepalese *Bambusa* species which do not root readily have been undertaken for the past three years. They have shown a few interesting factors which seem to restrict rooting and some methods of overcoming the limitations which they impose.

Literature review

It is known for a long time that bamboos vary greatly in their ability to root from culm cuttings and Troup (1921) recorded the relationship between rooting ability and the abundance of roots on the culm. McClure (1966) refined this method relating rooting ability to root abundance on central branch bases in the mid- culm region. Beyond these basic observations it would appear that very little is known as to why this is or how reluctant species can be persuaded to root. It has been pointed out (McClure, 1966; Soderstrom and Calderon, 1979; Xiong et al, 1980) that bamboos have received little attention in the more fundamental aspects of morphology, physiology , and propagation and consequently there does not appear to be a standard cutting, nor adequate guidance for selection of the best material for propagation. As far as simple vegetative propagation is concerned there is a substantial amount of information available, although it is widely dispersed in the literature and often a little contradictory.

Recently important advances have been made in the more sophisticated fields of propagation such as tissue culture and use of several growth-regulating substances (Huang and Murashige, 1983; Wang, 1981; Seethalakshmi et al, 1983) but such techniques are not necessarily relevant to the basic forest nurseries often encountered in the less developed countries,

For material selection both morphological and physiological characters have been discussed. Riviere and Riviere (1879) were among the first to appreciate the similarity between the swollen central branch base and the rhizome in many genera and its potential value in propagation. They found that inclusion of a part of the culm was essential for the branch base to successfully produce rooted plants, which was also supported by the findings of Prange (1974). Gupta and Pattanath (1976) showed that the physiological state of the culms was important for subsequent shoot production, although Azzini and Ciaramello (1978) could not improve rooting by supplying glucose solutions. McClure and Kennard (1955) showed how different species had different optimum ages for taking cuttings, and McClure (1966) suggested that this could be due to variations between bud development and the physiological materials and food reserves in supporting tissues. McClure (1973) and Hasan (1982) initiated studies into branch complement structure and development and further studies are needed for a good understanding of the correction factors.

Physiological conditions of plants are important to obtain cuttings. It is known from experience in other plants that the optimum time is often immediately prior to growth initiation in the plant's normal cycles. McClure (1966) described this as the end of the dry season for bamboos in his group I, although growth in branches usually commences several months earlier and experience has shown early spring to be best for these bamboos, (Gupta and Pattanath, 1976; Dai, 1981).

In order to make the best use of finite resources of cutting material it must be planted in a manner which will give the greatest number of plants. Cabanday (1957) undertook comparisons of whole culms, two-node cuttings, and single-node cuttings. From his results it would appear that single-node cuttings gave the greatest number of rooted shoots per culm used, although the success rate was not the highest. Similarly Dai (1981) showed that whole culms. partially severed between the nodes were more productive than uncut culms, although his culms still had the rhizomes attached. Medina et al (1962) and others have reported that horizontal cuttings are more successful than vertical or oblique ones. Although it has been observed that the environment is not the limiting factor in many cases (Hasan., 1980), Abeels (1962) reported that waterlogged conditions were not successful, and Khan (1972) found clay soil to be better than silty sand. McClure (1966) attributed some of his failures to insufficient irrigation.

Comparison of different trials is often difficult as most authors have used different criteria. Some reports of success have been based upon shoot production alone without any evaluation of rooting. Others have considered both shoot and root production as important and successful. Some authors only consider propagation successful when a clump has been established under field conditions, which vary greatly, and this appears as a stringent criterion. McClure (1966) gave the required features of a truly successful cutting as one which carries a bud that developed into a rhizome from which new rooted shoots had arisen. He used the term rhizome in a 'black and white' sense which may have obscured the potential transition between partially rhizomatous shoot bases and true rhizomes in his group I bamboos.

1983: Bambusa nutans trial

The method adopted in this first propagation attempt was the standard technique used by McClure and Kennard (1955) in Puerto Rico: shallowly burying entire two-year-old culms severed above the rhizome in March with branches trimmed back to 10cm. The environment was improved by shading and irrigating the loamy beds and by putting sealed polythene tunnels over two treatments with different irrigation regimes. Eighteen twelve-meter culms were planted with a total of 487 nodes, most of these bearing many branches with viable buds, giving several thousand shoots from several orders of branching arising in different orientations at different soil depths.

Evaluation after seven months showed an overall mean production of only 2.2 rooted plants per culm, with successful plants arising from only 8.8% of the nodes, and no significant differences between the treatments. McClure and Kennard (1955) had obtained between 9.4 and 28.7 plants from 12-meter lengths of four other Bambusa species, which suggests that Bambusa nutans is very reluctant to root indeed. This is backed up by its morphology. It is a bamboo of extremely fine form, with no trace of aerial root production or the nodal swelling associated with it.

Limitations to rooting did not appear to be environmental, as there were no significant differences between treatments with and without polythene tunnels to prevent desiccation. To look for other reasons why the shoots had not rooted, all nodes were excavated and carefully examined. This yielded more useful results than the quantitative evaluation of the treatments. Four factors which had limited the development of rooted plants were observed:

1. Firstly it was seen that at all except the very basal nodes, the only buds which gave rise to rooted shoots were on the base of the central branch. Buds from no other branches produced rooted plants, merely vigorous shoots.

2. Secondly it was observed that only when these shoots underwent a reorientation through the horizontal did they produce roots. In attaining the light and responding to gravitational stimuli they assumed a curving shape similar to the normal rhizome, and rooted from the curving basal portion which had a shorter first extended internode than found in shoots which went straight upwards and which never rooted (Fig. 1).

3. Thirdly, shoots which arose too deeply in the soil and could not quickly reach the light died before doing so.

4. Fourthly there were several shoots which had rooted, but died. There seemed little reason for this but it was also noted that the successfully rooted shoots had not initially grown as vigorously as others.

Thus it was seen that while B. nutans appeared to be a very reluctantly rooting species, there were several identifiable factors which limited rooting. It seemed there was potential for improving the performance by planting the material more suitably so that basal buds from the central branches faced in the correct direction at the correct soil depth at all nodes.

1984: Dendrocalamus hamiltonii and Dendrocalamus hookeri trials

To confirm and demonstrate the superior rooting of Dendrocalamus species with abundant aerial roots two culms of each species were planted with a further seven culms of Bambusa nutans for comparison. Conditions in the nursery were very arduous and only 5.5% of nodes of B. nutans produced rooted shoots. In contrast D. hamiltonii produced rooted shoots from 70% of nodes while D. hookeri produced them from 84% of the nodes. While branch development in Nepalese Bambusa species is very uniform along the culm it varies considerably in Dendrocalamus species. Three types of branch development were found. At the base of the culm the central branch was about the same size as in Bambusa species. Higher up the culm, it was either represented by a large bud or was well developed with a very large prolifically rooting base bearing large buds. Both Dendrocalamus species produced most abundant rooting from the central branch as it developed, it had a bud at planting, or from shoots from its basal buds if it had already been developed Shoots reorientated horizontally produced more roots than those which were vertical.

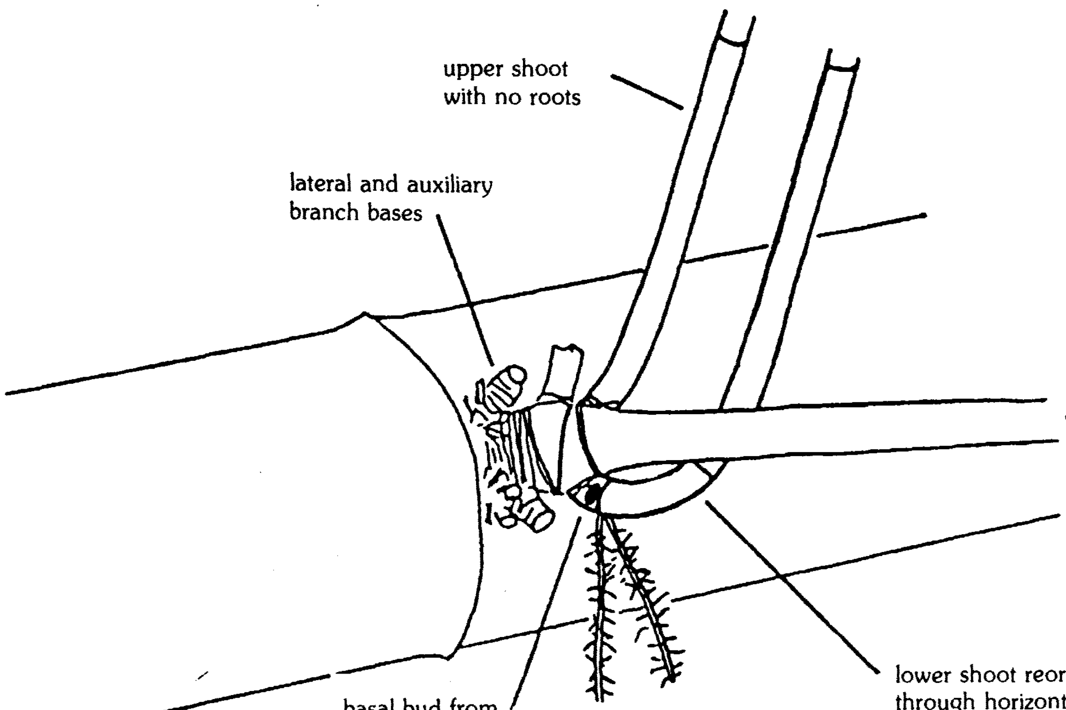


Fig. 1. Reorientating and rooting lower shoot and non-reorientating non-rooting upper shoot from central branch base in Bambusa nutans,

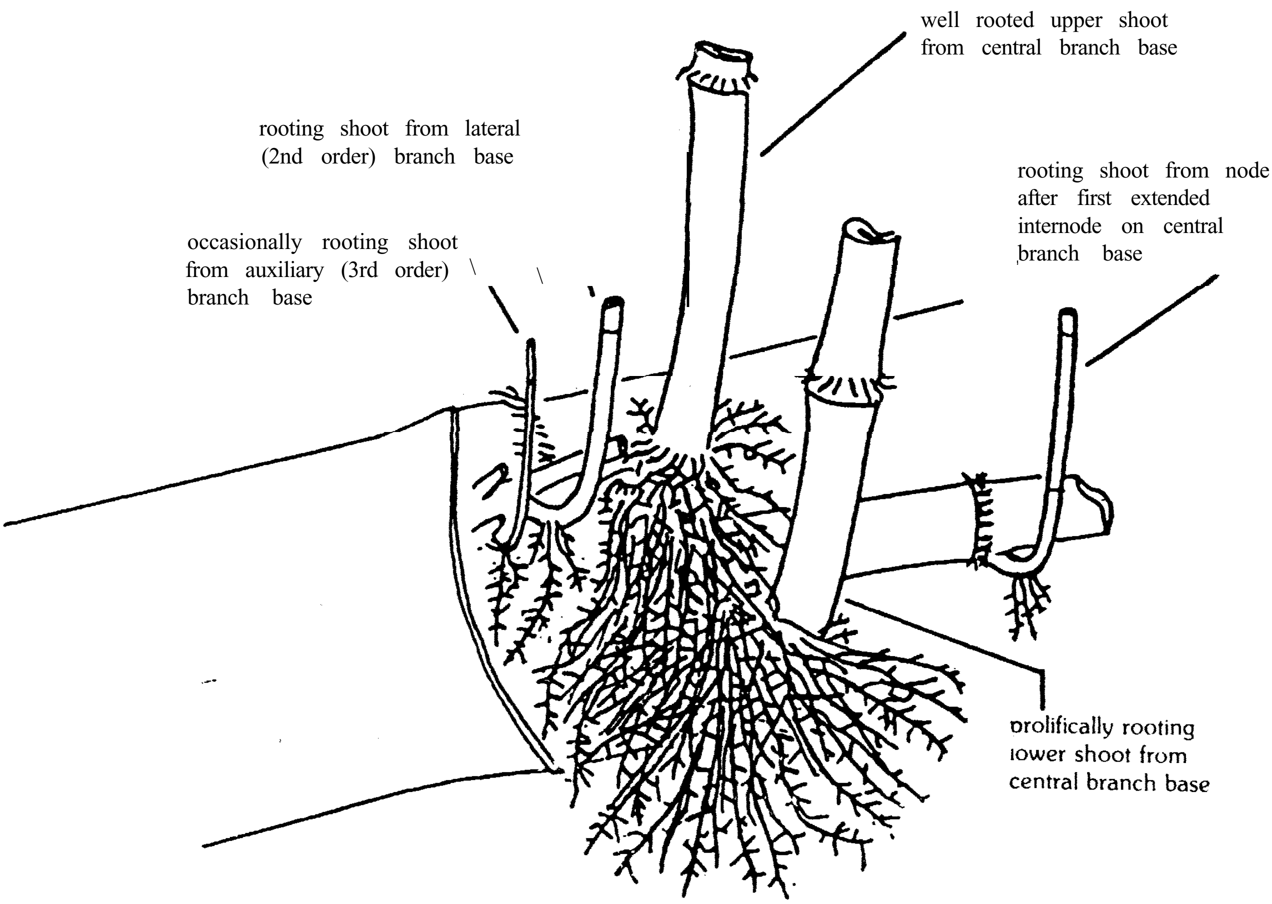
In addition, there were rooted shoots from several categories of branching which did not produce rooted shoots in B. nutans, and the overall rooting was much more prolific with many nodes producing more than one rooted shoot and several separate rooted plants (fig. 2). Under the arduous conditions development of the pre-existing roots was very limited and it was considered that the greater success in *Dendrocalamus species* was due to a greater overall inclination to production of roots rather than the support of pre-existing roots.

1984: Bambusa sp (tharu bans) trial of single-node cuttings

Bearing in mind the limitations to adequate rooting in Bambusa nutans seen in 1983 a new technique of planting was developed for Bambusa species. Two-year-old culms with a reasonably strong central branch were selected. The central branches were only cut beyond the first elongated internode, 15-25cm from the culm, while other branches were cut at 2-4cm both to promote development shoots from the central branch and to simplify orientation of the cutting.

In order to allow optimum orientation of developing shoots at the correct depth the culms were cut into single-node units. It had been observed that the die-back from cut ends in 1983 was negligible. It was also realised that water required for the rapidly developing shoots had to enter the culm at the severed ends. Dividing it into fifteen or so cuttings, all planted horizontally increased the surface area for water absorption by a factor of about fifteen. In this manner all the cuttings were planted in the same way as the nodes which had been successful in 1983, with certain small improvements in material selection (fig. 3). Cuttings were made from ten culms, planted under hessian shades in April, and watered daily until evaluation in November.

The cuttings developed as expected, showing the close similarities between the two *Bambusa* species. Those cuttings which rooted produced about the same number of roots as *Bambusa nutans cuttings had pro-*



Fig, 2. Rooting shoots from several categories of branching in Dendrocalamus hookeri

duced. Although 64% of rooted cuttings produced less than three roots from any single rooting shoot, and this was sufficient for further new axes to develop from the basal buds of these shoots, with prolific rooting, successively larger dimensions, and a closer similarity to full-sized rhizomes.

The overall success rate was 59.5% with an average of 11.3 plants per culm. Excluding the cuttings which came from the upper regions of the culm where its diameter was less than 3.5cm the success rate was 64.5% with productivity of 10.7 rooting nodes per culm. Although a strict comparison with the Bambusa nutans trial of the previous year cannot be made as this is a different species planted in a different nursery, it certainly appeared that by reducing the effects of the factors seen to limit rooting in B. *nutans* and planting single-node cuttings in the correct orientation, a satisfactory response could be obtained in this very similar species which also has no aerial roots at all. The stimulation of production of only a very few roots on certain shoots allowed the development of strongly rooted shoots from the basal buds giving viable plants in a predictable and fairly uniform fashion.

1984 Bambusa sp (tharu bans) trial – details of development

While it had been observed in B. *nutans* trial that only certain shoots in a particular orientation could root, the detailed development of such shoots and the interactions between shoots had not been followed closely. With three similar strong shoots arising from the central branch it was realised that there was potential for more than one shoot to root, and also potential for relative competition between these shoots and with the smaller shoots from the lateral and auxiliary branches.

Further studies in the removal of small

shoots suggested that they had not been diverting resources excessively. There were no significant .differences in root production between those cuttings with shoots removed (mean 3.41 roots, standard error of the mean (s.e.m.) 0.62) and those with shoots left intact (mean 3.94. s.e.m. 0.61). Further there was interaction between the upper (from the top of the branch base) and lower shoots (from the bottom). Eighty-eight percent of cuttings had a total of three shoots arising from the central branch base, ten percent had four shoots, and two percent had only two shoots.

Those cuttings with two shoots developing downwards obviously had more potential for producing roots than those with only one, and produced a mean of 4.6 roots (s.e.m. 0.59) as opposed to only 2.1 (s.e.m. 0.33) roots per cutting. Therefore it is desirable to plant the cuttings so that two shoots will develop downwards, to maximise the total rooting and also the number of rooted plants obtainable. The mean number of roots per rooting lower shoot was significantly higher in those cuttings with only one upper shoot to compete with (2.52, s.e.m. 0.35) than in those cuttings with two (1.63, s.e.m. 0.27).

It was noted that the cuttings which have no upper shoots at all would produce even more roots, and this is presently under investigation. It is clear that by planting the cuttings the correct way up, root production can be enhanced greatly. In this trial, cuttings planted the correct way up, produced a mean of 5.3 roots (s.e.m. 0.74) while those planted the other way up produced a mean of only 2.5 roots (s.e.m. 0.43). Seventy five percent of the cuttings in the former category successfully produced rooted shoots from the central branch base. There was still some visible domination of lower shoots by single vigorous non-rooting upper shoots however. To eliminate this influence altogether the bud can be destroyed at planting or the shoot removed as it emerges.

It is quite difficult to see the buds at branch base at the time of planting as they are covered by overlapping sheaths. However, the bud after the first extended internode on the central branch is clearly visible, and because of the alternate arrangement the orientation of this bud can act as a simple indicator of which way up the cutting should be planted, (Fig. 3). If this bud faces upwards there will almost always be two buds facing downwards at the branch base.

The major remaining limitation to successful rooting was suspected to be connected with the considerable delay between shoot and root production, which usually was around ten to fifteen weeks. Some healthy shoots still had not produced roots after as much as twenty weeks and several were damaged or had dried out before they could root. Preliminary inspection of ongoing trials has indicated that altering planting depth may be an effective and convenient way of controlling the timing of loss of apical dominance.

Discussion

The superior rooting ability of shoots arising from the base of the central branch is well known, but appreciable rooting ability of shoots from other branches in the complement of readily rooting species such as many Dendrocalamus species does not appear to be well known. This is important as it offers potential for producing more rooted plants from each node. The apparent effect of shoot orientation on root production is very interesting but needs further investigation. An experiment which aims to determine the effects of different environments on shoots reorientated in the same manner is underway. The development of a standard method of planting cuttings with a quantitative criterion of success offers scope for more accurate identification of limiting factors in producing rooting species and evaluation of techniques to overcome such poor responses.

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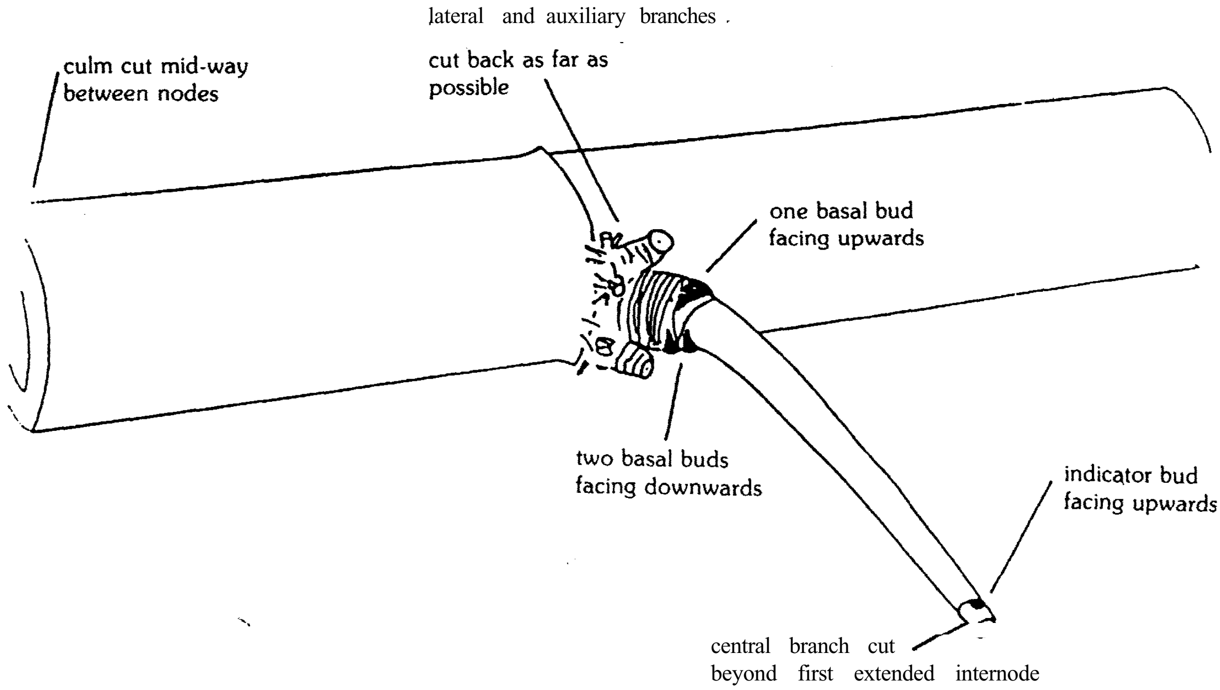
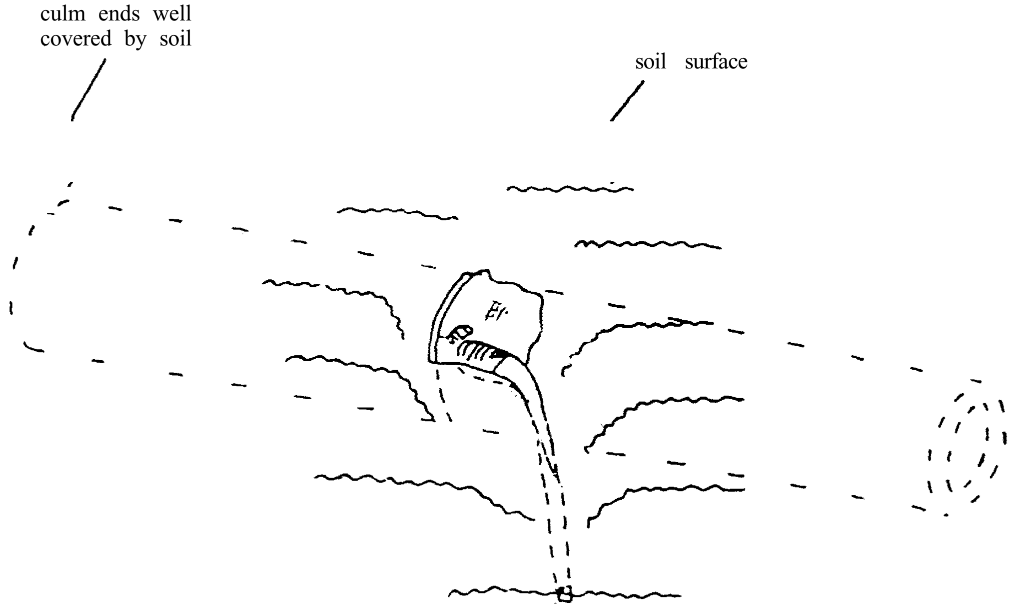


Fig. 3. a) Prepared single-node cutting of Bambusa species



b) Planting technique with culm and branch horizonral and only branch base not covered by soil.

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