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INVESTIGATIONS ON THE POSSIBILITY OF VEGETATIVE PROPAGATION OF BAMBOOS AND REEDS BY ROOTING STEM CUTTINGS

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INTRODUCTION

Bamboos are arborescent perennial grasses distributed widely from tropical to subtropical and temperate regions of the world. Taxonomically bamboos belong to the subfamily Bambusae of family Poaceae, consisting of about 75 genera and 1,250 species. More than 100 species belonging to 20 genera of bamboos are known to occur in India spread over an area of ca. 9.57 million hectare possibly the world's largest reserves (Varmah and Bahadur, 1980). Of about 30 species of bamboos reported from Kerala: ***Bambusa arundinacea*** (Retz.) Willd., ***Dendrocalamus strictus*** Nees, ***Ochlandra trarancorica*** (Bedd.) Benth. ex Gamble and ***Ochlandra scriptoria*** (Dennst.) C. E. C. Fischer are commercially important. ***B. arundincaea*** is a large thorny bamboo found throughout Kerala, in the plains as well as in the hills up to about 1000 m above msl. This is a clump forming species with culms reaching a height of about 20 to 30 m and diametre of about 15 to 20 cm (Gamble, 1886). The flowering in ***B. arundinacea*** occurs at an interval of 30 to 45 years and after flowering the clumps dry up. ***D. strictus*** is also distributed in Kerala, especially in the dry areas up to 1000 m above msl. Clumps are dense with strong culms which are more or less solid, reaching about 7 to 20 m in height. It flowers gregariously over large areas after an interval of 30 to 40 years (Troup, 1921), but occasionally it has been observed to flower sporadically also. The sporadic flowering, however, does not produce as much good seeds as the gregarious flowering. ***Bambusu blacooa*** Roxb., naturally occurring in the hill ranges of Assam, Bengal and Bihar and introduced in Kerala, is also a caespitose bamboo with dull greyish-green culms, reaching a height of about 15 to 25 m and diameter ranging from 5 to 15 cm. ***O. travancorica*** and ***O. scriptoria (O. rheedii)*** are the two main species of reed bamboos found in Kerala. ***O. travancorica*** is an erect, shrubby or arborescent species occurring from low to high elevations while ***O. scriptoria,*** gregarious and shrubby in nature, is generally found on river banks. The most commonly used reed, ***O. travancorica*** flowers at an interval of seven years (Gamble, 18%) after which the whole patch dries up, creating a gap of about 2 to 3 years in the availability of the raw material.

As a long fibered raw material bamboo occupies an important place in paper and pulp industry; bamboo pulp is suitable for the production of high quality papers. Of the 4.2 million tonnes of bamboo raw material, about 50% goes to the paper and pulp industries (Varmah and Bahadur, 1980). To meet the ever increasing demand of bamboo as a raw material, an urgent need is felt to increase the area under bamboo cultivation either by raising plantations or by promoting natura! regeneration. The possibility of raising large-scale plantations from seeds is limited since most of the bamboos produce seeds after long intervals ranging from 3 to 120 years (Sharma, 1980). Planting of offsets is considered to be a most reliable method, but it is ideal for only small-scale plantations. For large-scale planting use of offsets poses numerous problems and has been considered to be impractical (Hasan, 1977). Extraction of offset is very cumbersome and the risk of damaging the rhizome, roots and buds is high, especially in clump forming bamboos (Uchimura, 1.979). Furthermore, as the extractable offsets per clump are limited, they are not available in large number. The offset material is also bulky and difficult to transport.

Propagation of bamboos using culm segments and branch cuttings ensures the availability of enough planting material, which is easy to extract and handle. Earlier workers have tried this method with limited success. Vegetative propogation of bamboos by induction of rooting of culm and branch cuttings or nodal 'chips' has definite advantages over other methods of vegetative propagation.

The present study was undertaken to find out a suitable method to induce rooting in culm and branch cuttings of commercially important bamboos and reeds of Kerala. As the growth regulating substances are known to play an important role in the rooting of cuttings indifferent species, the efficacy of various auxinic and non-auxinic chemicals was tried. The influence of season, if any, on the rooting was also studied.

REVIEW OF LITERATURE

Investigations on vegetative propagation of bamboos were initiated as early as 19th century when Pathak (1899) tried propagation of ***Dendrocalamus strictus*** using 3 to 5-year-old culm cuttings. Although sprouting was good in the initial stages, the cuttings failed to establish during summer. Curran and Foxworthy (1912) reported (cf. Bumarlong and Tamolang, 1980) that cuttings could be used for propagating the Philippine bamboos ***Bambusa blumeana*** Schultes f., ***B. vulgaris*** Schr. and ***Gigantochloa levis*** (Blanco) Merr. with 34, 32 and 6 per cent success respectively. Later, Foxworthy (1917) (cf. Bumarlong and Tamolang, 1980) obtained 59 per cent and 40 per cent survival respectively in stump and culm cutting of ***B. blumeana.*** Survival was better when cuttings were planted unsplit (Cabanday, 1957) (cf. Bumarlong and Tamolang, 1980). Agleam (1960) also got similar response in the case of ***G. levis.*** Propagation of six bamboo species viz. ***Bambusa ploymorpha*** Munro,

B. tulda Roxb., ***DendrocaIamus longispathus*** Kurz., ***Thyrsostachys oliveri*** Gamble, ***Dendrocalamus stricrus*** and ***Bombusa arundinacea*** (Retz.) Willd. was attempted by Dabral(l950) and only first four species could be rooted. In another study using single noded cuttings, though sprouting occurred, due to fungal attack and decay they failed to establish. Chinte (1965) reported better survival rates with one-year-old, 3-noded cuttings of ***B. vulgaris*** (60 per cent) and ***Gigantochloa aspera*** Kurz. (28 per cent); ***B. blumeana*** and ***G. levis*** failed to root. About 70 per cent survival of ***B. blumeana*** was obtained with marcots (wherein branches are pruned, covered with a mixture of garden soil and leaf mould, and wrapped with coconut husk or coir) and 28 per cent by ground layering of one-year-old culms (Cabanday, 1957) (cf. Bumarlong and Tamolang, 1980).

Rooting ability of cuttings taken from different parts of the culm was found to be variable. In most cases, basal portions of the culm responded better than the top and middle ones (Mabayag, 1937; Chinte, 1965).

Branch cuttings of ***Gigunrochloa verticillata*** Munro and ***Sinocalamus oldhami*** (Munro) McClure were successfully propagated by White (1947). McClure and Durand (1951) and Delgado (1949) also propagated some of the bamboos using branch cuttings, which were slow to form roots. Generally branch cuttings form good planting material in six to thirty months time depending upon the biological condition of the cuttings and the season of the year when the cuttings were taken (Hasan, 1977).

Studies with ***B. polymorpha*** and ***D. strictus*** indicated that April is the suitable month for vegetative propagation of these bamboos (Gupta and Pattanath, 1976). The effect of season on the rooting of branch cuttings of nine bamboo species was studied by White (1947) and be found that the maximum rooting (about 16 per cent) occurred in December and minimum during September (about 3 per cent); maximum number of species rooted during March (six species) and December (five species). As the age of cuttings is concerned, planting material of ***B. vulgrais*** taken from 6-month-old culms gave better rooting than those from I-and 2-year-old culms. In ***T. oliveri, B. tulda,*** and ***B. polymorpha*** culms less than a year old did not sprout.

There are only a few reports about the effect of climatic factors on rooting of bamboos. Cuttings of ***B. blumeana*** sprouted and survived under direct sunlight than in full shade (Mabayag, 1937). However, studies of Delgado (1949) indicated that cuttings planted in shade rooted better than those in direct sunlight. Abeels (1962) while studying the propagation of ***B. vulgaris, D. strictus, G. asper*** and ***Oxytenanthera abyssinica*** Munro observed that planting medium such as soil and sand of nursery beds or water logging did not affect rooting. However, he noticed that if the middle portion of the internode was perforated and filled with water, to maintain high humidity in the culm cavity, rooting was promoted vigorously. Rainfall in the preceding month of extraction of cums appears to be an important factor influencing rooting (white, 1947).

Growth regulating substances have been used to induce rooting in cuttings of of many species in forestry as well as in Agriculture (Nanda, 1970). These substances are known to influence various processes of development viz. cell division, elongation, differentiation, rnobilisation of nutrients and activity of hydrolysing enzymes. Since rooting of cuttings was usually poor in the propagation methods described above, various workers (Bumarlong, 1977; Suzuki and Ordinario, 1977; Uchimura 1977) used plant growth regulators for promoting the rooting response in bamboos. Uchimura (1977) found that, of the three growth regulators (IAA, lBA and NAA), cuttings treated with 100 ppm of IBA for 24 hours gave better rooting percentage and formation of longer roots in ***B. vulgaris.*** In a similar study with ***B. blumeana*** using different concentrations of I.AA, IBA and NAA, Bumarlong (1977) observed the highest dry weight and mean lenghth of roots for cuttings treated with 600 mg/l of NAA while maximum number of roots per cutting was obtained with 200 mg/l of NAA. Higher rate of survival was recorded in the cuttings treated with IBA (13 per cent) over control in ***B. blumeana,*** 5 per cent in ***B. vulgaris*** and 6.5 pa cent in ***Dendrocalamus merrilianus*** (Elm.) Elm. (Suzuki and Ordinario, 1977). However, normal concentrations of growth regulators have no effect on rooting of branch cuttings (White, 1947; Delgado 1949).

A truly successful method for vegetative propagation of bamboos has not been found (Banik, 1980). Successful propagules must develop sufficient roots and rhizome so as to ensure their survival in the field after planting. The observations of earlier worker (Pathak, 1899, Lin, 1962, 1964; Chinte, 1965) were limited only to the rooting; ability which does not necessarily indicate the success of rooted cuttings after transplanting in the field. Clones do not become fieldworthy unless rhizomes have been formed and new shoots start emerging (Hasan, 1980).

MATERIALS AND METHODS

The experimental material of the following species of bamboos and reeds were collected from different localities in Kerala as shown below.

	Species of bamboo/reed		Locality
1.	***Bambusa arundinacea***	—	Kollathirumedu (Chalakudy Forest Division) Vazhikkadavu, Nellikutha, Vadapuram and Mancheeri (Nilambur For. Dvn.)
2.	***B. balcooa***	—	Peechi (Trichur For. Dvn.)
3.	***Dendrocalamus strictus***	—	Vazhikkadavu (Nilambur For. Dvn.)
4.	***Ochlandra travancorica***	—	Vazhachal (Chalakudy For. Dvn.)
5.	***Ochlandra scriptoria***	—	Vazhachal (Chalakudy For. Dvn.)

Trials of ***O. travancorica, O. scriptoria*** and ***B. balcooa*** were carried out at Peechi while that of ***D. strictus*** at Nilambur and ***B. arundinacea*** both at Peechi and Nilambur.

I. PREPARATION OF THE PROPAGATION MATERIALS

i. Culm cuttings

Approximately 2-3-year-old culms of all the above bamboos and reeds were extracted from healthy clumps, by cutting them at the ground level. The top parts of the culm bearing leaves and side branches were removed. Care was taken not to damage the nodal buds while removing the side branches. These culms were brought to the laboratory as quickly as possible and made into 2-noded cuttings leaving about 5 to 7 cm of culm portions at either end beyond the node. Using a sharp chisel, a small cut was made at the centre of the internodal region to provide an opening to to the culm cavity (Plate I 1). In ***D. strictus*** where the internodal cavity is very narrow, culm cuttings were treated as such by 'dip method'.

ii Branch cuttings

Side branches of ***B. arundinacea*** and ***B. balcooa*** were removed from a few of the basal nodes of the culms and secondary branches trimmed carefully without damaging the buds. From these, 2-noded cuttings having a diameter of 1 to 1.5 cm were prepared.

iii. Nodal-bud-chips

Nodal-bud-chip as a propagation material was used in the case of ***B. arundinacea.*** After removal of all the side branches, small chips were cut out from the node of the culm along with the rhizomatous buds intact.

II. CHEMICAL TREATMENT

Various growth regulating substances, namely, indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA), coumarin and boric acid (BA) were used for treating the different propagation materials.

i. Preparation of solutions

Stock solutions of IAA, IBA, NAA and coumarin were prepared by dissolving weighed quantity of the substance in 2 ml of ethyl alcohol (95%). This was made up to 1 1 by adding de-ionized water. BA was dissolved directly in water and solutions of appropriate concentrations prepared. Two concentrations i. e., 10 and 100 ppm were used for all the growth regulating substances.

ii. Methods of Treatment

Cavity method: Culm cuttings of ***B. arundinacea, B. bclcooa, O. travancorica*** and ***O. scriptoria*** were chosen at random and grouped into lots of 10 each. These were treated by "cavity method" in which 100 ml solution of a growth regulating substance was poured into the culm cavity (Plate I2). The opening was then wrapped and tied with a polythene strip (6 cm wide) (Plate I3) so that the solution does not spill out. The treated cuttings were kept horizontally with the opening facing upwards.

Dip method Culm cuttings of ***D. strictus***, branch cuttings of ***B. arundinacea*** and ***B. balcooa*** and nodal-bud-chips of ***B. arundinacea*** were treated by dipping their lower portions in the chemical solution for 24 hours (Dip method). Controls were maintained for all the treatments where the propagation meterial was treated with de-ionized water alone.

III. PLANTING

The nursery beds at Peechi were filled with sand and soil (1:3) while at Nilarnbur it was sand only. Treated culm cuttings were placed horizontally in the nursery beds ensuring that the opening faced upwards (Plate 1 4) and covered with a uniform layer of soil/sand, 2 to 3 cm deep. The nodal-bud-chips were planted ,with their buds facing upwards in earthenware pots (30 x 15 cm) filled with sand and soil (1:l). The beds were watered regularly in the morning and evening with 30 to 40 1 of water per bed (10 × 1 m) at each watering except during the rainy season (June-August). Water logging was avoided. The nursery beds were provided with a thatch

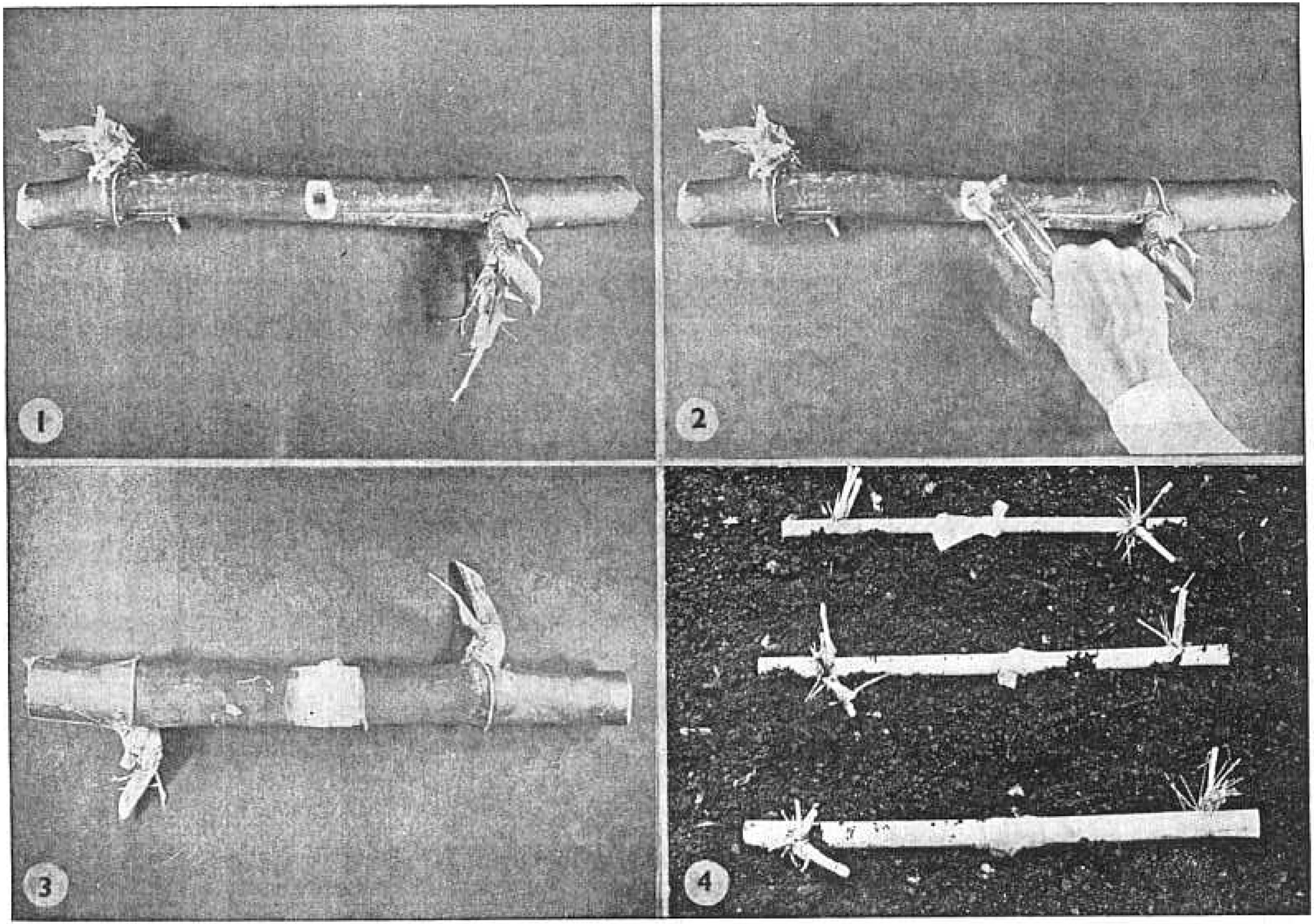


Plate Photographs illustrating the 'cavity method' of treating two-noded culm cuttings of *Bambusa arundinacea*. 1, a cuttting showing an opening made at the centre of the internode; 2, acqueous solution of a growth regulating substance is being poured into the culm cavity; 3, after the treatment the opening of the cutting is wrapped and tied with a polythene strip; 4, treated cuttings are placed horizontally on the nursery bed during planting.

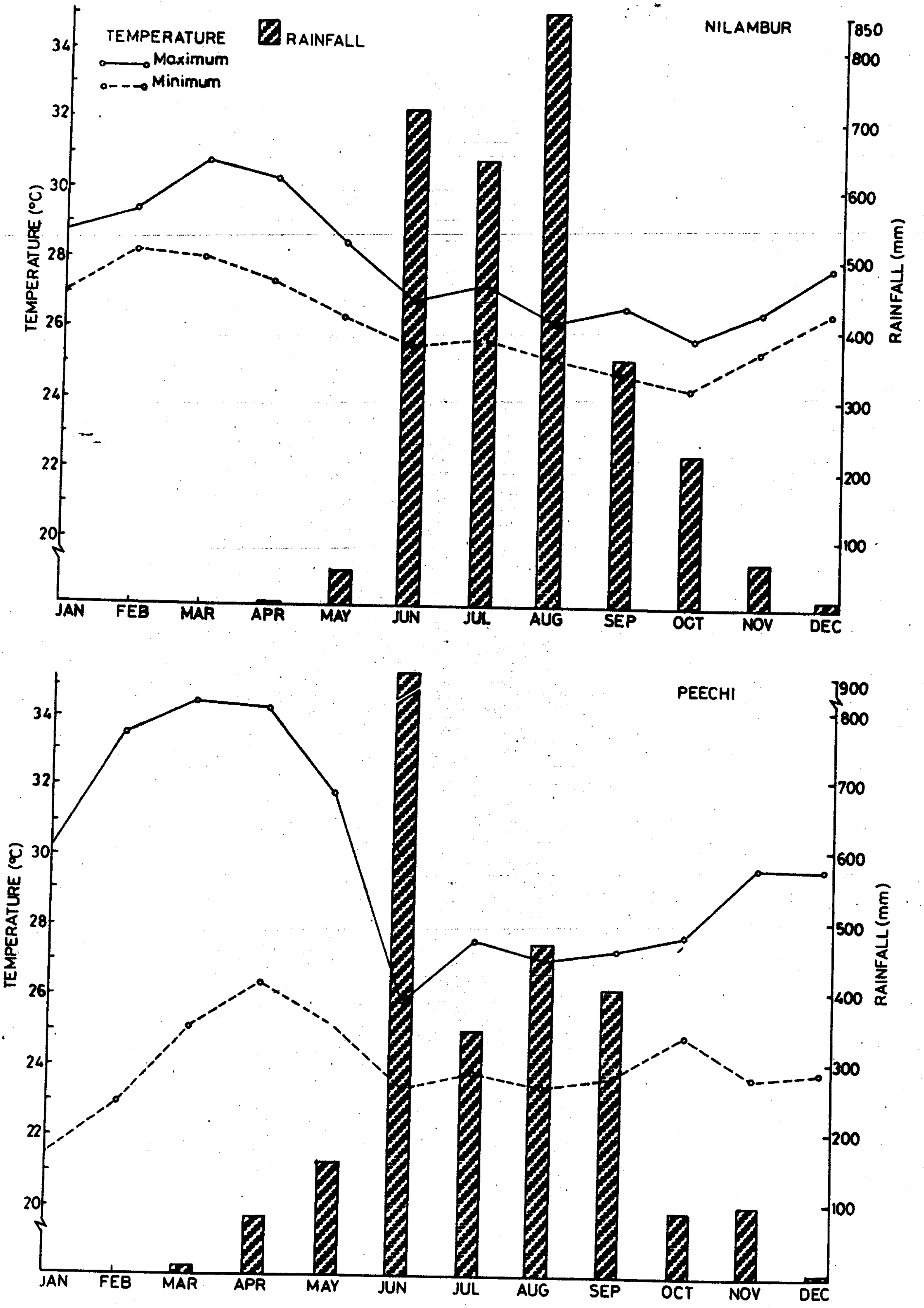


Fig. 1. Variation in temperature and rainfall recorded at Nilambur and Peechi during the experimental period, (June 1981 - May 1982).

to protect the cuttings from direct sun light and sun scorch. The thatch was removed after the onset of monsoon.

Prophylactic treatment against insect and fungi

One week prior to planting, the nursery beds were drenched with 40 of 0.01% (a. i.) of aldrin 30 EC solution and 0.05% (a. i.) of Bavistin to protect the cuttings from termite and fungal attack. After sprouting of the cuttings, if any fungal attack was noticed a soil drench of Bavistin 0.05%, (a. i.) was applied immediately.

IV. SEASONAL EFFECT ON ROOTING

To study the seasonal effect on induction of rooting fresh material was extracted every month and as far as possible all the treatments were repeated. The data on rainfall and temperature were collected from Metereological Stations at Peechi and Nilambur for the experimental period i.e. from June 1981 to May 1982 (Fig. 1).

V. OBSERVATIONS

The cuttings planted at monthly intervals for one year were uprooted after six months and observations recorded **on** percentage of rooting, number and length of roots, as well as number and height of sprouts per rooted cutting. For trials conducted at Peechi, data were collected only on percentage of rooting and sprouting response. The data were statistically analysed using analysis of variance and Duncan's new multiple range test (Keppel, 1973) after applying appropriate transformations. Since there was fairly large variation in the sub-class numbers, unweighted analysis of cell means was carried out only as a quick test for detecting the presence of interactions. Ranking of treatments was done with respect to each character and the common treatments picked out from the best group for each character.

RESULTS

I. PROPAGATION OF BAMBOOS

i *Bambusa arundinacea*

Percentage of rooting: The percentage of rooting obtained at Nilambur in response to various treatments during different months are presented in Table 1. In general, all the treated cuttings rooted in January, February, March, May and September while the response varied during other months. except in some treatments. Treatment with IAA l00 ppm during the month of January responded with 80 per cent rooting but the response of this treatment varied during other months. Cuttings treated with 100 ppm of both IBA and NAA during the month of March gave 70 per cent rooting, while the control had only 20 per cent. Further, control cuttings (without treatment) did not root in January, June and October; maximum (40 per cent) rooting occurred in November.

The percentage of rooting obtained in the rooting trials conducted at Pecchi are shown in Table 2. Treatment with IAA l00ppm during the months of June and July gave 70 and 80 per cent rooting respectively. Cuttings treated with 10 ppm of IAA and NAA and 100 ppm of coumarin during the month of March were also promising (60 percent). In control sets a maximum of 30 per cent was obtained during March, April and May.

Analysis of variance of data on percentage of rooting obtained at both the locations viz. Nilambur and Peechi are presented in Table 3. Since there were only single replicate values, the mean squares for the different factorial effects in the analysis of variance could not be tested for their significance. The values of meansquares show that higher order interaction could not be assumed non significant. Treatments showing a minimum of 70 per cent and above rooting response are given in Table 4.

Number of roots: The responses obtained in number of roots per cutting, with various GRS treatments are presented in Fig. 2. The highest gain achieved over control is 100%. The variance due to control vs. treated did not turn out significant because their difference did not remain constant over months as shown by the significant interaction. IBA and coumarin each at 100 ppm in April gave highest mean number of roots followed by NAA 10 ppm in the same month (Fig. 2). Curiously a definite trend was noticed in the rooting response of various treatments with regard to the months. There was a gradual increase in the number of roots

Table 1. Data showing the percentage of rooting obtained in various treatments to culm cuttings of *Bambusa arundinacea* at Nilambur (N = 10)

Treatments \ Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Control	0	30	20	20	10	0	20	30	30	0	40	10
IAA_{10}	30	50	20	10	20	0	20	0	40	30	10	10
IAA_{100}	80	30	60	30	20	10	10	50	50	40	20	0
IBA_{10}	50	60	60	40	20	10	20	40	40	20	60	20
IBA_{100}	60	50	70	10	50	20	30	50	50	20	10	20
NAA_{10}	60	40	60	0	40	0	10	40	30	20	20	10
NAA_{100}	40	40	70	20	40	10	0	50	40	30	10	0
$Coumarin_{10}$	50	40	40	10	20	20	10	40	40	10	10	10
$Coumarin_{100}$	10	10	50	20	30	10	0	60	50	0	0	20
BA_{10}	30	60	30	20	20	0	20	50	40	20	0	0
BA_{100}	40	60	30	20	40	0	10	30		20	0	0

Table 2. Data showing the percentage of rooting obtained in various treatments to culm cuttings of *Bambusa arundinacea* at Peechi (N =10)

Months / Treat-ments	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
control	10	10	30	30	0	30	20	0	0	0	20	10
IAA_{10}	30	10	60	30	10	30	20	20	40	30	30	20
IAA_{100}	30	20	40	30	10	70	80	20	40	40	20	40
IBA_{10}	10	10	40	20	10	40	20	20	20	0	10	10
IBA_{100}	10	40	40	0	0	20	0	0	0	0	30	10
NAA_{10}	10	30	60	50	30	30	0	20	0	30	30	10
NAA_{100}	10	30	40	0	0	40	20	40	10	20	20	10
$Coumarin_{100}$	20	10	40	0	0	40	0	0	20	0	20	30
$Coumarin_{100}$	20	0		10	20	40	0	0	0	20	10	30

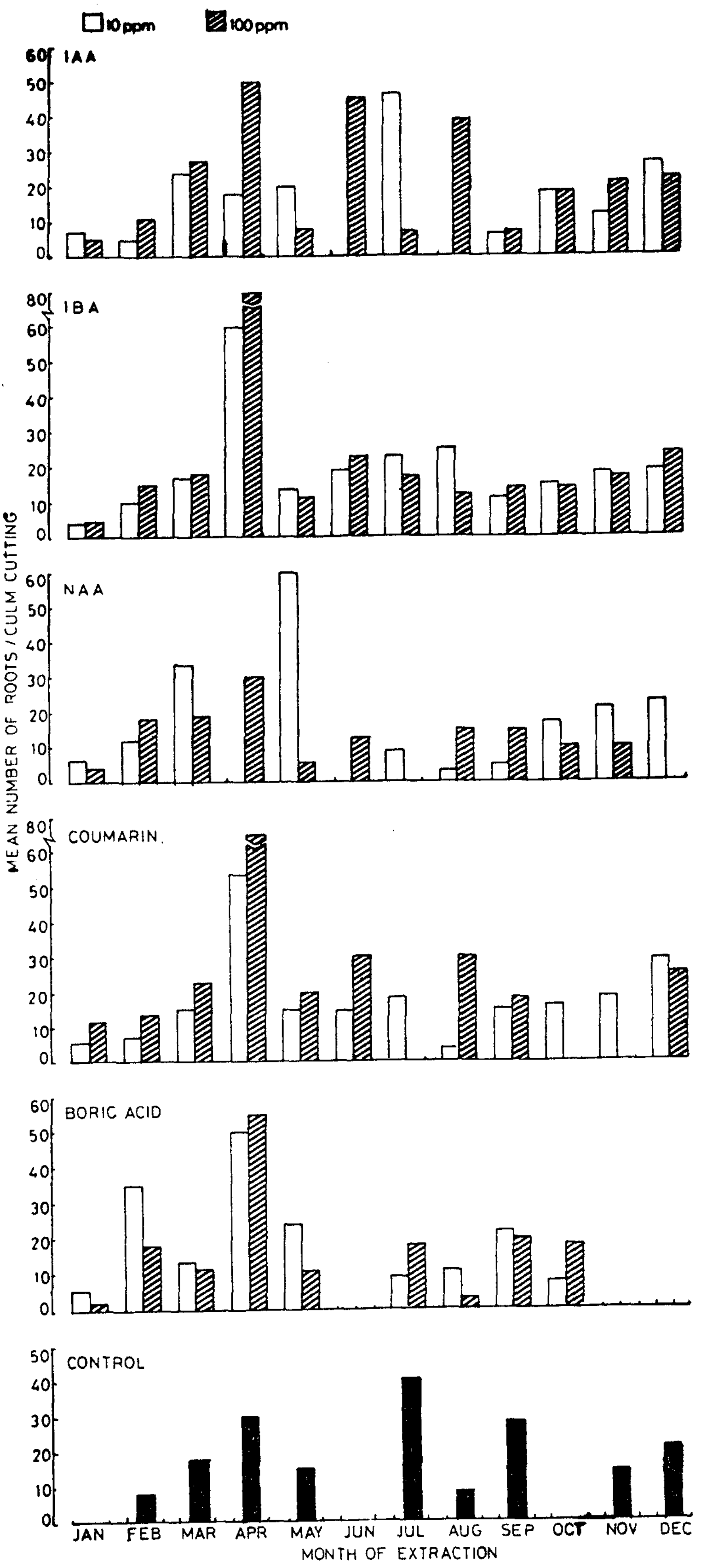


Fig. 2. Number of roots per culm cutting of *B. arundinacea* in response to various growth regulating substances.

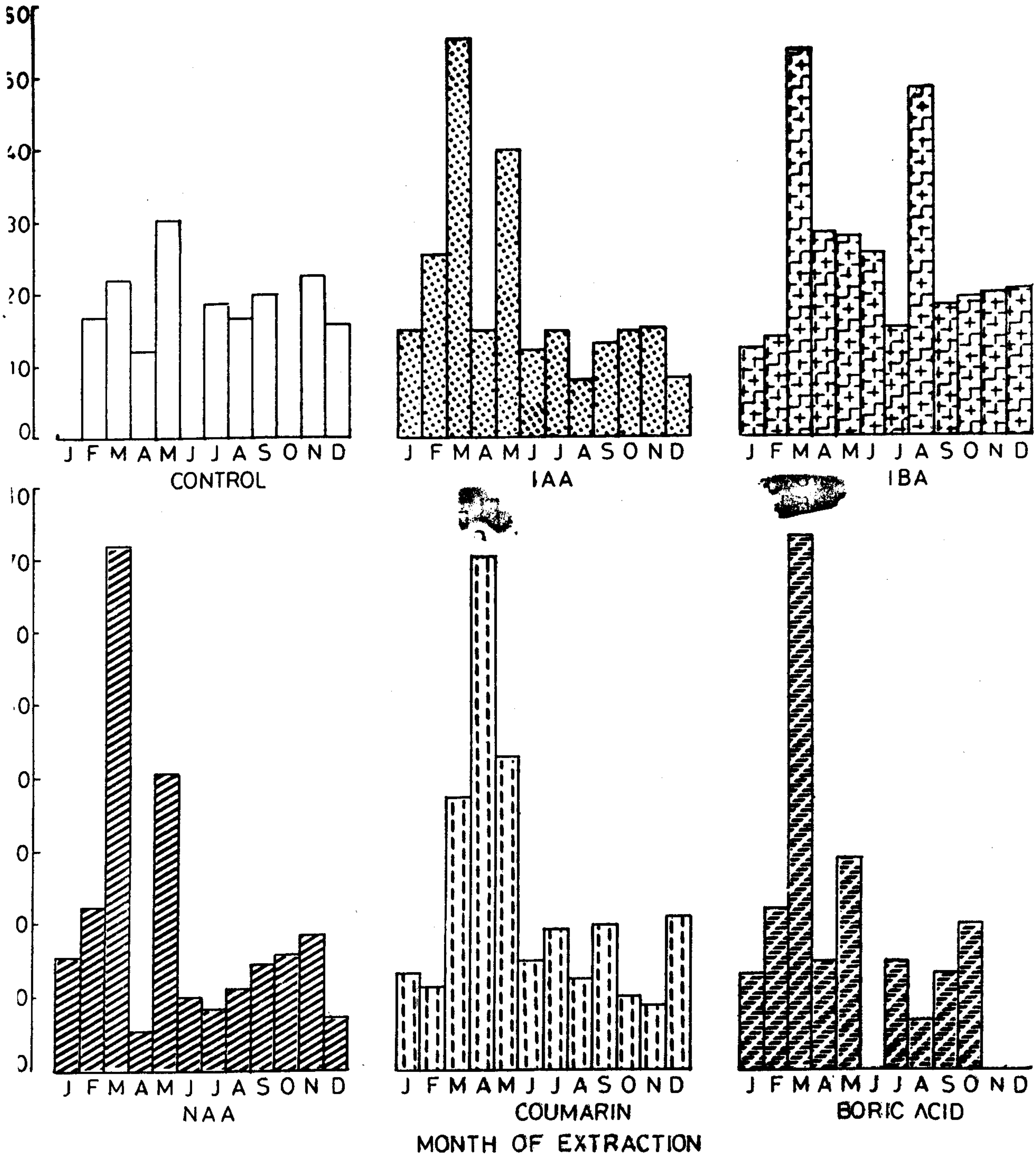


Fig. 3. Length of roots per culm cutting of *B. arundinacea* with various growth regulating substances. Each bar represents the pooled mean of two concentrations (10 and 100 ppm) of a GRS.

from January to April and then it slowly decreased. In the latter part of the year only IAA 100 ppm during the months of June and August and 10 ppm during July were better than other treatments. In the case of control, July and September were best.

The observed F-values for the different factorial effects are presented in Table 3. The interaction between month, GRS and concentration was found highly significant and the performance of GRS at both the levels was not consistent over months. Therefore, the best groups of treatment combinations were arrived at by the use of DMRT and these are shown in Table 4.

Length of roots: The interactions between months, GRS and their concentrations were not significant as seen from the Table 3. Since the variation in the mean length of roots per cutting was comparable with the variation in the length of individual roots, the variances due to these two sources were pooled and used as error for testing the significance of their effects. This component was high enough to make effects due to all other sources except months as nonsignificant. In general, difference between control and treated also did not turn out significant due to the same reason. The length of roots was significantly influenced by the month of extraction of cuttings and treatment. Generally, cuttings rooted during summer months (February to May) developed longer roots, the best response being obtained in March (Fig. 3).

Number of sprouts: The three factor (month, GRS and concentration) interactions were found highly significant at both the locations (Table 3) and hence the individual treatments were compared for their effect on number of sprouts per cutting. The best group of treatments arrived at by DMRT are given in Table 4. The pattern of difference between control and treated changed over months as seen from the corresponding interactions. The number of sprouts per rooted cutting obtained in the trials conducted at Nilambur was highest during February (10 ppm of IBA and 100 ppm of coumarin) and August (100 ppm of coumarin). The maximum gain over control was 250% during February. Though in control sets maximum value was obtained in August, the gain over control was minimum (Fig. 4). Results of the trials conducted at Peechi also revealed that during February a treatment of coumarin 10 ppm yielded maximum number of sprouts, while during April 100 ppm of the same GRS was found favourable (Fig. 5).

Height of sprouts: In general, the cuttings treated and planted during the months of May, January and February had taller sprouts than those in other months for the Nilambur trials (Table 5) while at Peechi it was during June to December (Table 6).

Table 3. Analysis of variance of the data on rooting and sprouting response of ***Bambusa arundinacea*** to various treatments

Sources	M.S.S.	F-values			
	Percentage of rooting	No. of roots/ cutting	Length of roots/ cutting	No. of sprouts/ cutting	Height of sprouts/cutting
Nilambur					
Month	12541.69	17.82**	8.89**	22.44**	7.90**
GRS	1264.02	12.42**	0.92^{ns}	9.55**	4.56**
Concentration	56.97	0.44^{ns}	0.87^{ns}	2.41^{ns}	0.02^{ns}
Month x GRS	3614.25	7.36**	1.20^{ns}	2.84**	1.10^{ns}
Month x Concentration	1057.10	9.48**	0.47^{ns}	1.38^{ns}	0.26'"
GRS x Concentration	470.09	1.50^{ns}	1.45^{ns}	4.10**	1.10ns
Month x GRS x Concentration	2821.25	5.14**	0.81^{ns}	2.49**	0,84ns
Control vs. treated	519.69	1.02^{ns}	2.15^{ns}	14.07**	0.10ns
Control vs. treated x month	1231.61	9.56**	0.43^{ns}	4.62^{ns}	2.58*
Peechi					
Month	434.54			41.55**	44.23**
GRS	791.90			26.02**	92.44**
Concentration	0.35			17.40**	4.72*
Month x GRS	102.34			4.55**	11.51**
Month x Concentration	62.71			3.59**	3.75**
GRS x Concentration	137.73			8.42**	11.39**
Month x GRS x Concentration	94.47			14.68**	9.65**
Control vs. treated	354.29			125.81**	72.54**
Control vs. treated x month	99.13			8.70**	11.71**

** P = 0.01; * P = 0.05; ns not significant

Tab1e **4.** List of selected best treatment groups for ***Bambusa arundinacea, Dendrocalamus strictus, Ochlandra travancorica*** and ***O. scriptoria*** arrived at by DMRT (except for the percentage of rooting)

Sl. No.	Species	Rooting response: Percentage of rooting	Rooting response: No. of roots per cutting	Rooting response: Length of roots per cutting	Sprouting response: No. of sprouts per cutting	Sprouting response: Height of sprouts per cutting
1.	***Bambusa arundinacea***	(Minimum 70 per cent and above)				
	a. Nilambur trials	IAA100 ppm Jan. IBA 100 ppm Mar. NAA 100ppm Mar.	IBA 100 ppm Apr. NAA 10 ppm.May NAAl00 ppm May	March	IBA 10 ppm Feb. Coumarin 100 ppm Feb., Aug.	IBA Jan., May
	b. Peechi trials	IAA 100 ppm June, July			Coumarinl0 ppm Feb. Coumarin100 ppm April	IAA10 ppm July, Aug.
2.	***Dendrocalamus strictus***	(Minimum 60 percent and above) IBA 100 ppm Mar. IAA 100 ppm Mar. NAA 100 ppm Mar.	NAA 10 ppm Oct. Coumarin 10 ppm Mar. IAA100 ppm April, October	Feb. Nov.	Feb. March	NAA Feb. Coumarin Feb. IAA Oct.
3.	***Ochlandra travancorica***	(Minimum 50 percent) Coumarin 10 ppm April Coumarin 100 ppm March, May NAA 100 ppm April Control June			IAA 10 ppm March IAA 100 ppm March IBA 100 ppm March	NAA 100 ppm April Coumarin 10 ppm April, May
4.	***O. scriptoria***	JBA 100 ppm March			Not influenced	IAA100 ppm March, June IBAl0ppmFeb.

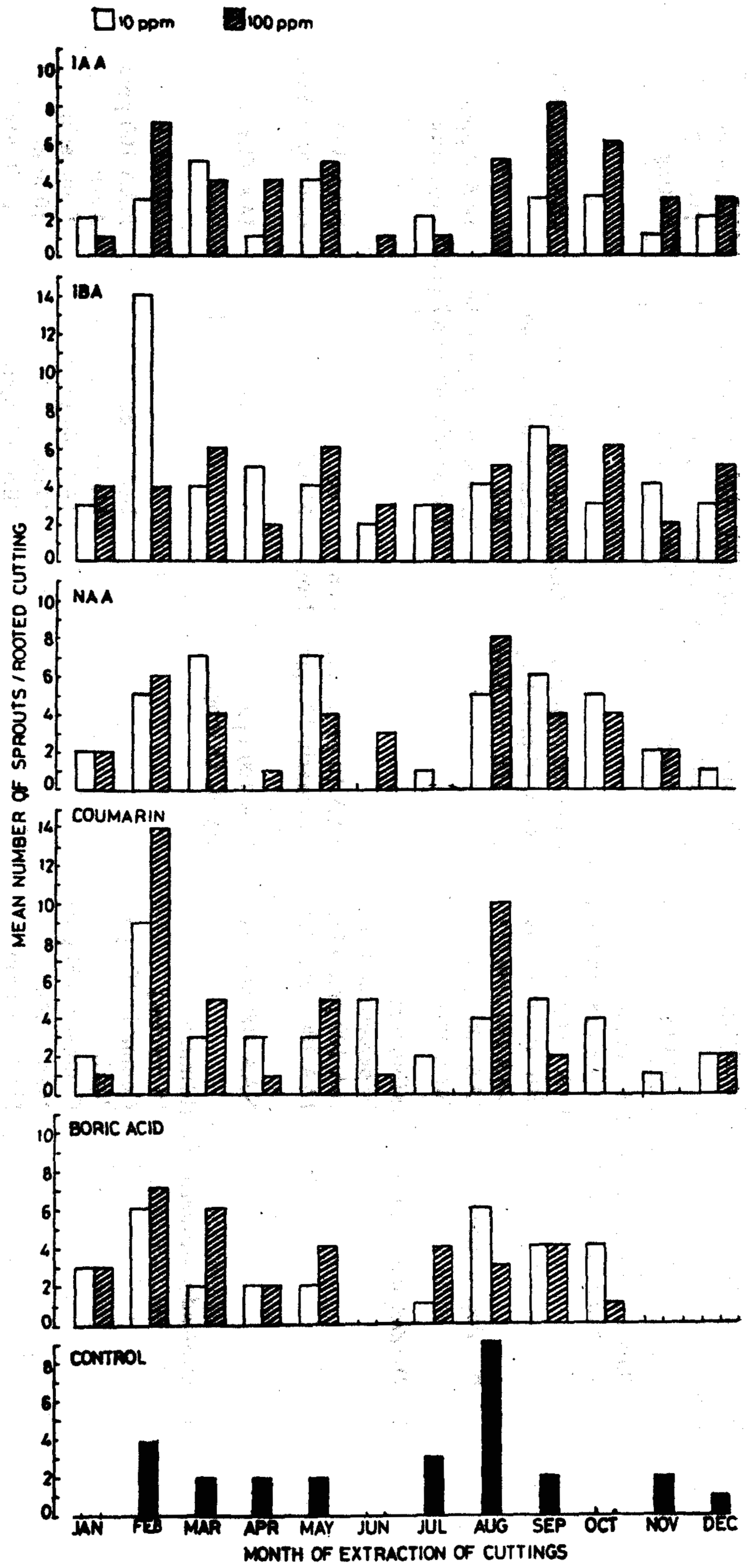


Fig. 4. Number of sprouts per rooted cutting of *B. arundinacea* in response to various growth regulating substances.

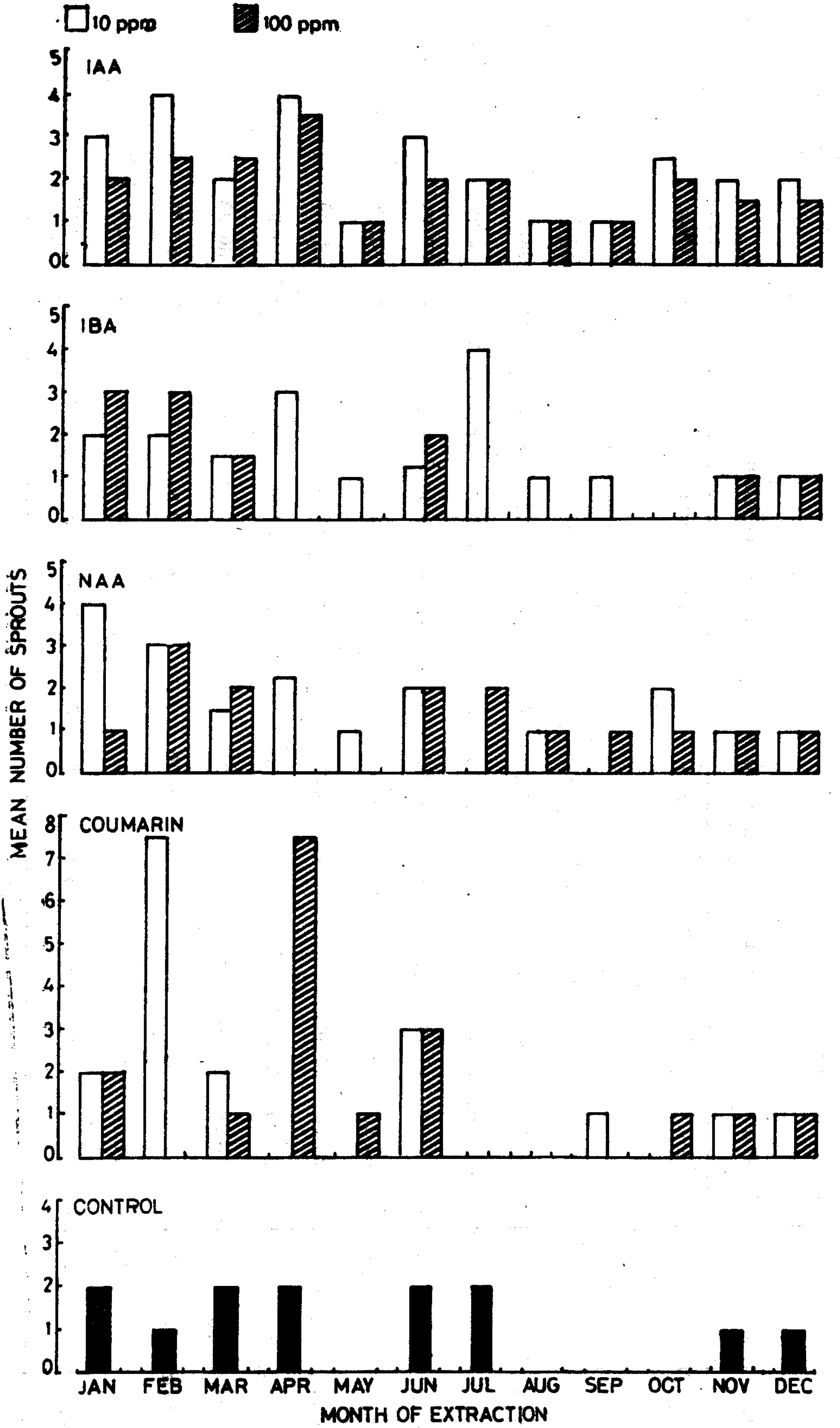


Fig. 5 Number of sprouts per rooted cutting of *B. arundinacea* in response to various growth regulating substances.

Table 5, Mean height of sprouts (in cm) per rooted culm eutting of *Bambusa arundinacea* (Nilambur)

Treat-ments / Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Control	0.0	54.33	61.42	25.0	87.5	0.0	45.58	40.66	31.39	0.0	9.0	20.00
IAA$_{10}$	81.39	34.00	30.33	20.0	73.75	0.0	43.00	0.0	17.60	20.0	5.5	33.20
IAA$_{100}$	82.33	30.33	71.57	55.6	93.00	15.00	30.30	21.71	48.80	13.0	20.0	52.08
IBA$_{10}$	71.53	41.66	49.93	33.0	78.50	30.25	14.66	42.25	45.00	18.0	19.0	57.78
IBA$_{100}$	81.63	42.40	60.25	35.0	41.16	25.00	24.40	38.33	29.60	36.0	12.0	63.64
NAA$_{10}$	33.27	23.25	35.40	0.0	54.71	0.0	32.25	23.60	34.00	16.0	18.0	26.80
NAA$_{100}$	49.3	98.00	29.66	27.5	63.00	18.53	0.0	31.48	65.61	20.0	0.0	0.0
Coumarin$_{10}$	51.00	70.00	29.16	80.0	46.00	35.00	18.00	25.00	29.15	15.0	10.0	36.33
Coumarin$_{100}$	32.86	72.00	54.82	48.5	40.80	16.50	0.0	31.14	39.66	0 .0	0.0	56.33
BA$_{10}$	32.46	27.00	66 16	56.0	17.60	0.0	27.00	28.76	33.33	8.0	0.0	0.0
BA$_{100}$	41.16	30.17	41.43	31.5	31.93	0.0	30.50	27.23	40.0	12.0	0.0	0.0

Table 6. Mean height of sprouts (in cm) per rooted culm cuttings of *Bumbusa arundinacea* (Peechi)

Treat-ments / Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sept.	Oct.	Nov.	Dec.
Control	132.0	81.5	83 0	80.0	0	181.0	150.0	0	0	0	198.0	204.0
IAA$_{10}$	182.5	144.0	159.0	101.0	59.5	3M.5	341.0	310.0	280.0	282.0	203.0	281.0
IAA$_{100}$	98.0	93.0	167.0	108.3	101.5	362.0	311.0	284.0	203.5	203.0	301.0	262.0
IBA$_{10}$	104.0	111.5	188.5	154.5	68.0	109.0	289.0	195.0	0	0	281.0	194.0
IBA$_{10}$	90.5	131.0	100.5	0	0	286.0	0	0	0	0	280.2	234.0
NAA$_{10}$	101.0	171.5	208.0	150.0	75.0	242.0	0	261.5	189.5	189.5	193.0	191.0
NAA$_{100}$	191.0	141.0	154.0	0	0	156 0	200.0	200.0	209.0	209.0		142.0
Coumarin$_{10}$	193.0	109.0	101.0	0	0	198.0	0	0	0	0	103.0	199.5
Coumarin$_{100}$	101.5	0	198.0	190.0	109.0	264.0	0	0	82.3	82.5	198.0	138.5

The height of sprouts was significantly influenced by month and GRS, while none of the interactions among the factorial effects were significant for the trials conducted at Nilambur (Table 3). Though GRS x concentration interaction was not statistically significant, there was considerable difference in height between the two concentrations (10 and 100 ppm) of NAA which was 74.75 cm in February, through this varied in other months (Table 5). Since the control and treated groups responded differently in various months their overall difference turned out non-significant, but control vs. treated x months interaction came out significant. As the trials conducted at Peechi is concerned, the influence of month, GRS and their interaction were highly significant (Table 3). The selected best groups of month, GRS and concentration are shown in Table 4.

It appears that no ,GRS could bring about desired response in all the characters simultaneously in a particular season. Though IAA 100 ppm during January and July gave the highest percentage of rooting (80%),the rooted cuttings were not vigorous. The next higher percentage of rooting (70%) was obtained with 100 ppm each of IBA and NAA during March. By giving maximum importance to percentage of rooting and ensuring a satisfactory vigour of sprouts and roots, a treatment with either IBA 100 ppm or NAA 100 ppm during March stands out as the best (Plate 11).

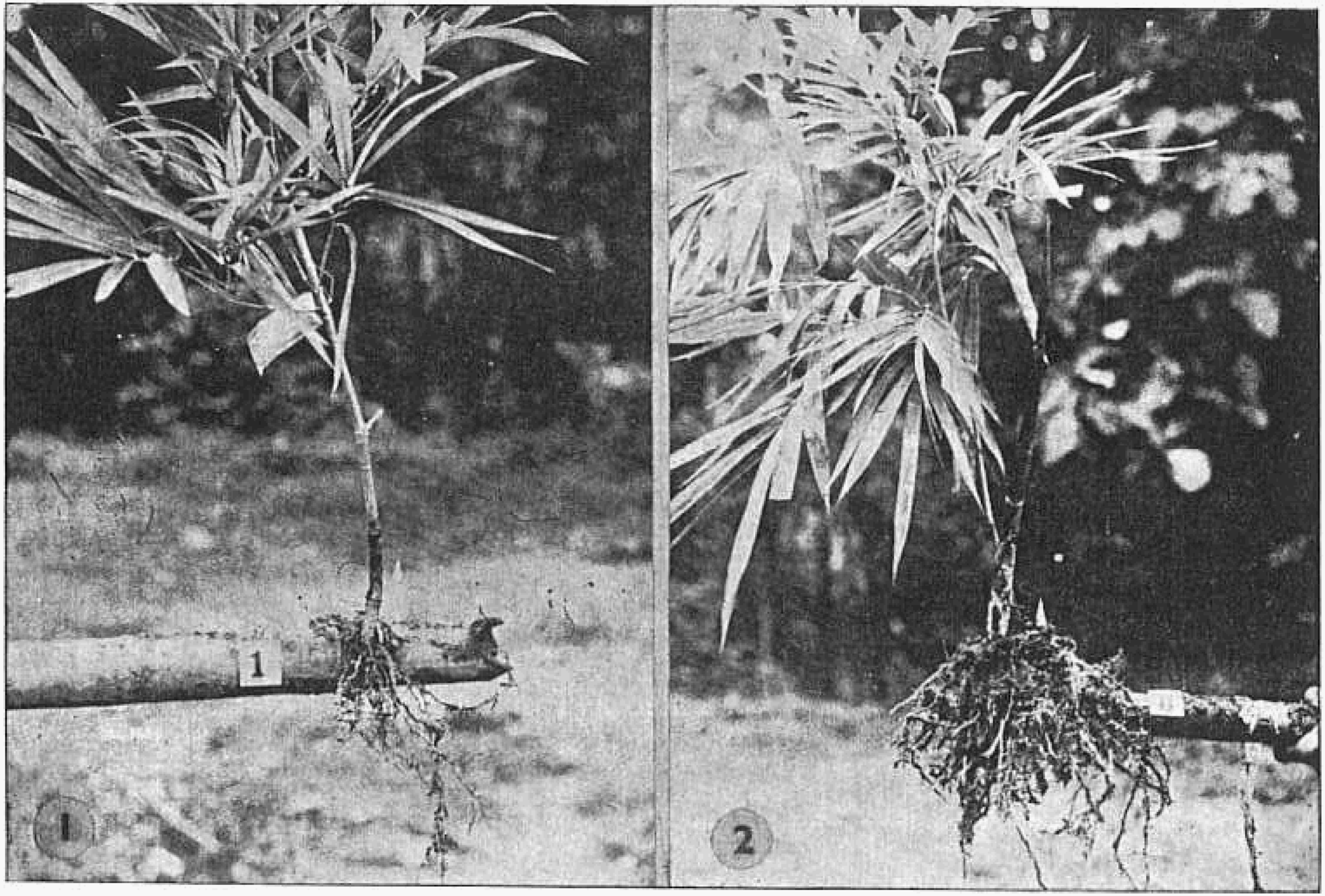
Some preliminary rooting trials with branch cuttings and nodal-bud-chips

Propagation of branch cuttings and nodal-bud-chips are more advantageous than culm cuttings since they are removed during smoothening of bamboo culm for commercial utilization. Preliminary trials conducted with both branch cuttings and nodal-bud-chips of ***B. arundinacea*** indicated the possibility of rootingthem by treating with a suitable growth regulating substance (Plate III). About 40% (with IBA 10 ppm)and 20% (with IBA100 ppm) rooting was obtained in branch cuttings and nodal-bud-chips respectively. Detailed investigations are, however, required for standardising suitable treatment combinations to obtain maximum rooting and sprouting responses.

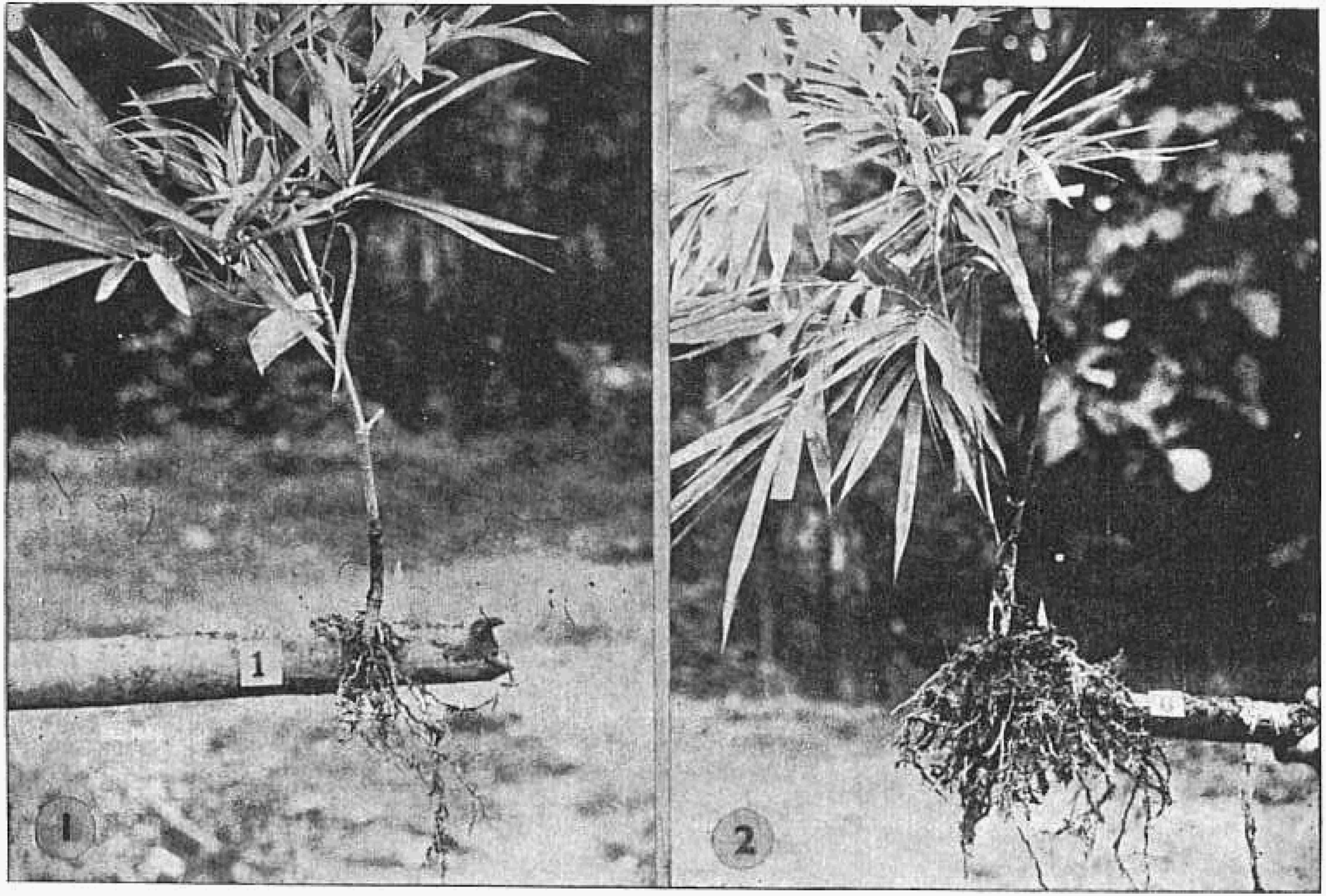
The method of planting i. e., vertical or horizontal influenced the vigour of sprouts and roots and also the period required for rhizome formation. In branch cuttings of ***B. arundinacea*** planted vertically as well as horizontally only the latter developed vigorous sprouts and roots occasionally from both the nodes (Plate III). Furthermore, the formation of rhizome was also rapid in horizontally planted cuttings,

ii *Dendrocalamus strictus*

Percentage of rooting Generally, the rooting response was maximum during February and March while none of the treatment could attain minimum of 50 per cent



Rooting and sprouting culm cuttings of *Bambusa arundinacea* response treatment with growth regulating substances. control (untrea 2. treated .AA 100 ppm



Rooting and sprouting culm cuttings of *Bambusa arundinacea* treatment with growth regulating substances. control untreated): 2 100

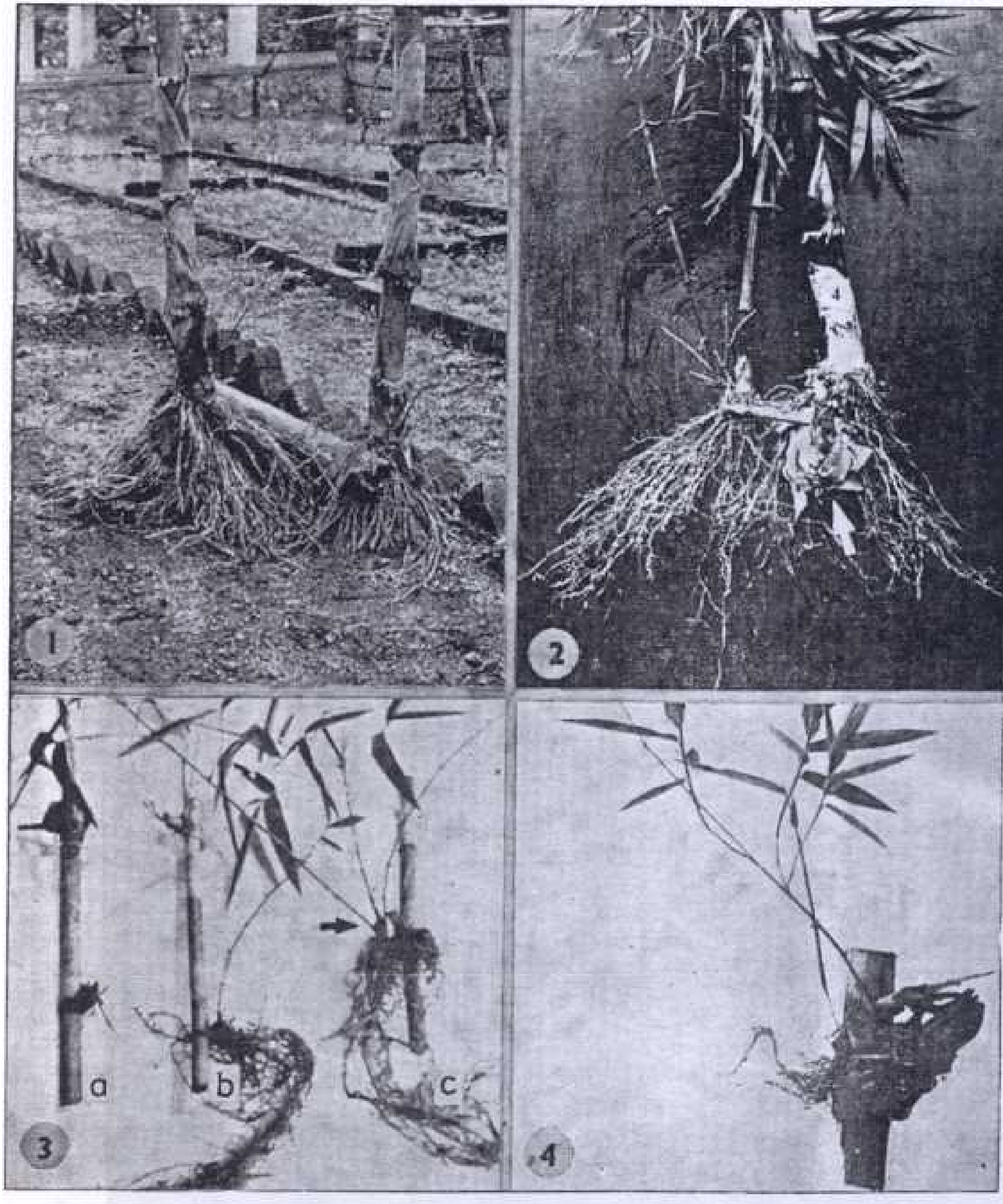


Plate III. Performance of different propagation materials. 1, a culm cutting of *Bambusa arundinacea* (treated with NAA 100 ppm) rooted at both the nodes; 2, a branch cutting planted horizontally (treated with IBA 10 ppm). Note the development of a stout rhizome (marked with an arrow) at one of the nodes; 3, branch cuttings planted vertically a, untreated; b, two-noded cutting treated with IBA 10 ppm; c, one-noded cutting treated with IBA 100 ppm. Note the development of a young shoot (marked with an arrow) 4, a nodal-bud-chip treated with IBA 100 ppm.

rooting during the period April to December. Treatment with 100 ppm IBA gave maximum percentage (70) during March, followed by 100 ppm each of IAA and coumarin during the same month (Table 7).

Analysis of variance of data is given in Table 8. As mentioned for ***B. arundinacea*** the factiorial effects for the percentage of rooting could not be tested due to the inherent limitations. The results of treatments showing a minimum of 60 per cent rooting are presented in Table 4.

Number of roots per cutting: Maximum number of roots per cutting was obtained during October with IAA 100 ppm, followed by NAA 10 ppm in the same month (Fig. 6). Besides, good rooting response was also observed during March and November (coumarin 10 ppm), April (IAA 100 ppm) and September (NAA 100 ppm). Control sets showed maximum response during April, September and October. These months seem to be congenial for getting good response. The three factor interaction was found highly significant (Table 8). The best groups of treatments as analysed using DMRT are shown in Table 4. The variance due to control vs. treated x month was not significant.

Length of roots: Generally, the cuttings treated and planted during summer months (February, March and April) had longer roots. Control and IAA treated cuttings had longer roots during August, while it was during August and September for NAA and coumarin treatments (Fig. 7). All the main effects and interactions were found nonsignificant as shown in the Table 8.

Number of sprouts: ,Month of extraction influenced the number of sprouts rather than different GRS or their concentrations. None of the interactions turned out statistically significant (Table 8). A perusal of the data shows that NAA in February and September and coumarin in September gave better response (Fig. 8).

Height of sprouts: During February, NAA and coumarin yielded maximum height of sprouts, while in October control and IAA were the best (Fig. 9). The interaction of month and GRS was highly significant, but the interaction between month, GRS and their concentrations was not significant (Table 8).

It is observed that as in the case of ***B. arundinacea*** any particular GRS could not bring about the desired responses in sprouting and rooting simultaneously in any particular month of the year. Eventhough treatment with IBA 100 ppm during March yielded 70 per cent rooting, the vigour of sprouts and roots of the cuttings was unsatisfactory. By giving importance to percentage of rooting, as well as to the vigour of sprouts and roots of the cutting, a treatment with NAA 100 ppm during the period of February to March is considered best.

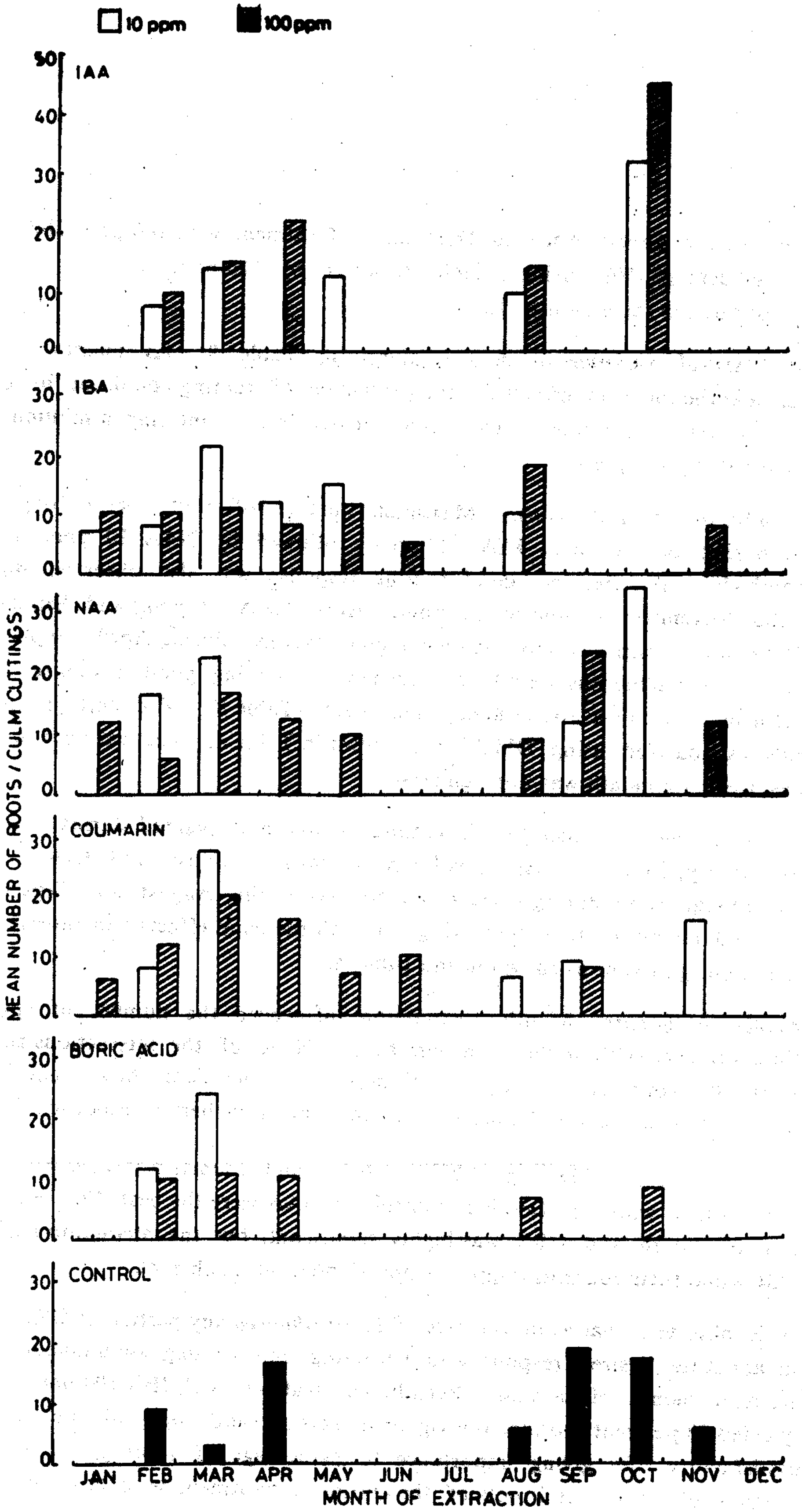


Fig. 6. Number of roots per culm cutting of *D. strictus* with various growth regulating substances.

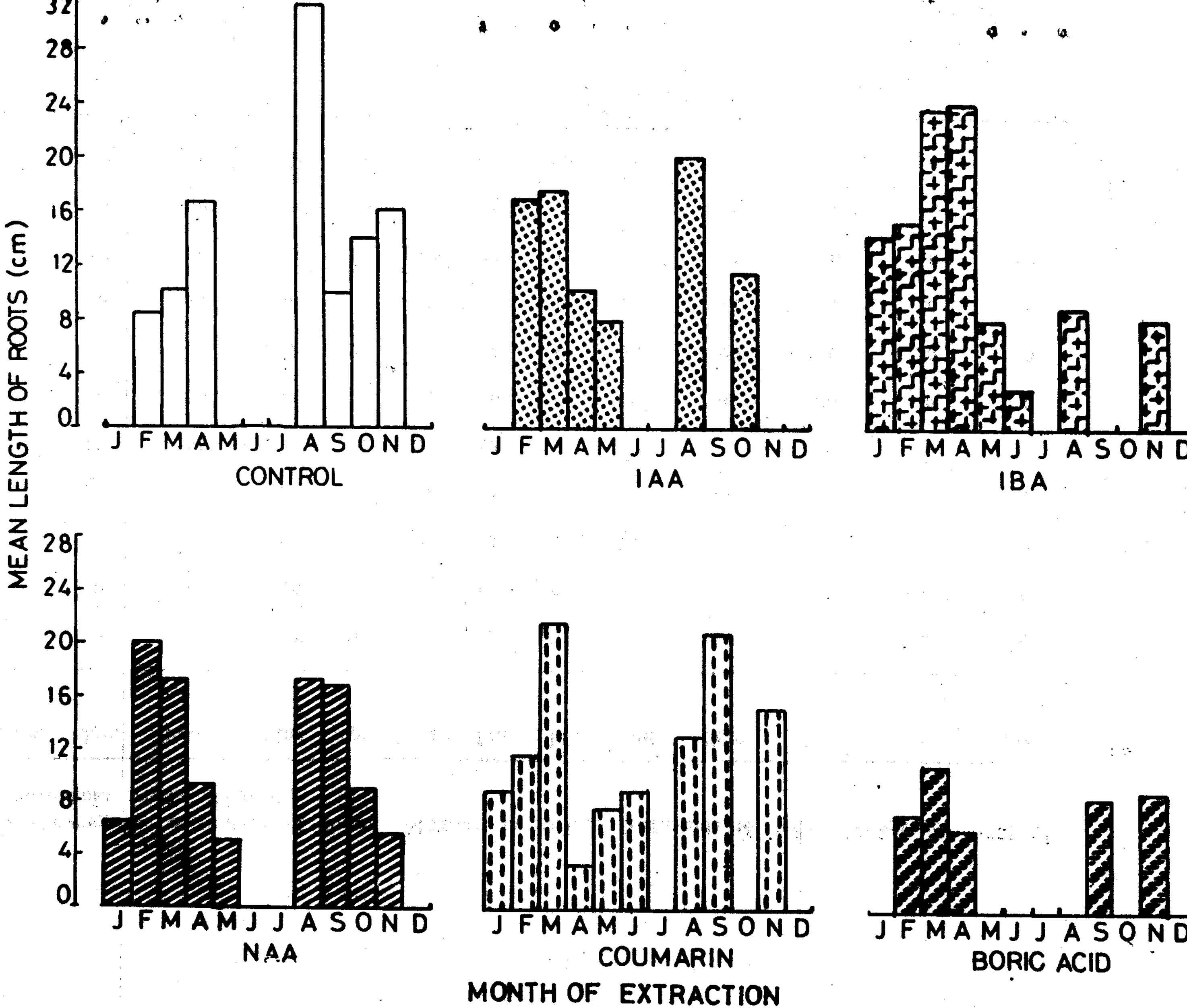


Fig. 7. Length of roots per culm cutting of *D. strictus* with various growth regulating substances. Each bar represents the pooled mean of two concentrations (10 and 100 ppm) of a GRS.

Table 7. **Data showing the percentage of rooting obtained in various treatments to culm cuttings of *Dendrocalamus strictus* (N = 10)**

Treatments \ Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Control	0	10	50	10	0	0	0	30	20	20	20	0
IAA_{10}	0	30	20	0	10	10	0	10	0	10	0	0
IAA_{100}	0	43	60	10	0	0	0	10	0	10	0	0
IBA_{10}	10	40	30	10	10	0	0	10	0	0	0	0
IBA_{100}	10	40	70	10	20	10	0	20	0	0	10	0
NAA_{10}	0	50	40	0	0	0	0	10	40	30	0	0
NAA_{100}	10	40	60	20	10	0	0	30	20	0	20	0
$Coumarin_{10}$	0	50	60	0	0	0	0	20	20	0		0
$Coumarin_{100}$	10	50	40	10	10	10	0	0	30	0	0	0
Boric $acid_{10}$	0	30	20	0	0	0	0	0	0	0	0	0
Boric $acid_{100}$	0	40	50	10	0	0	0	30	30	10	0	0

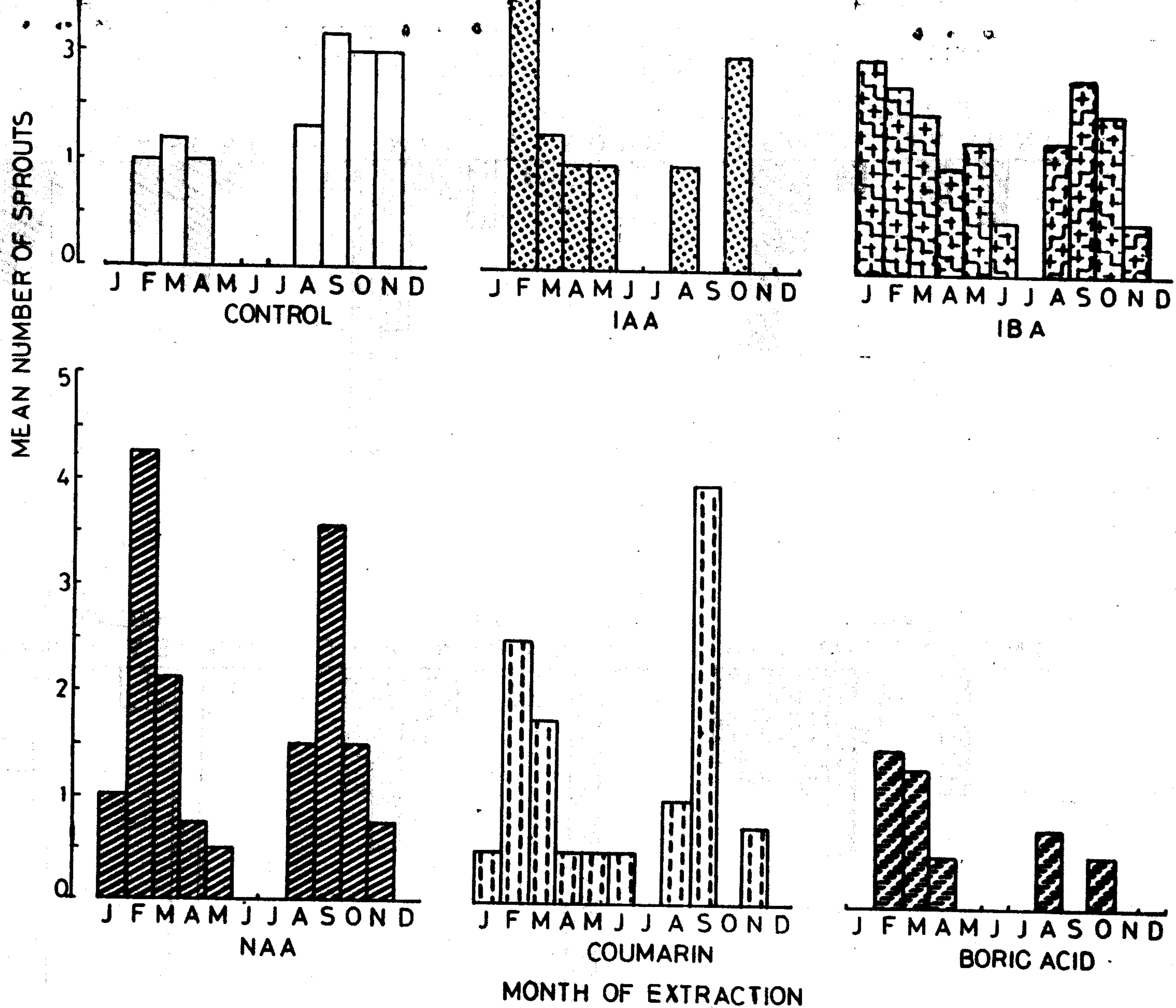


Fig. 8. Number of sprouts per rooted culm cutting of *D. strictus* in response to various growth regulating substances. Each bar represents the pooled mean of two concentrations (10 and 100 ppm) of a GRS.

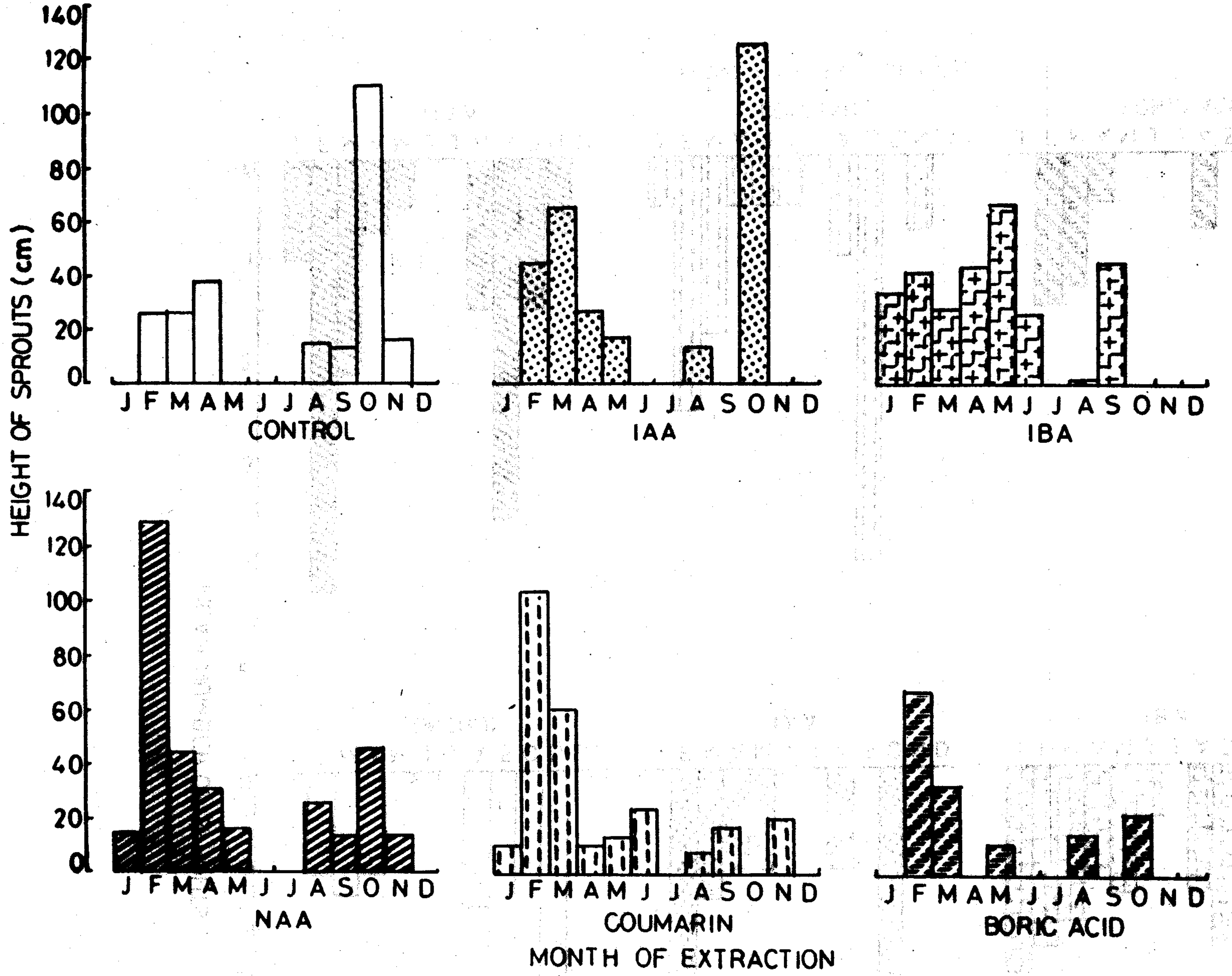


Fig. 9. Height of sprouts per rooted culm cutting of *D. strictus* in various growth regulating substances. Each bar represents the pooled mean of two concentrations (10 and 100 ppm) of a GRS.

Table 8. Analysis of variance of the data on rooting and sprouting responses of *Dendrocalamus strictus* to various treatments

Source	M.S.S.	F - Values			
	Percentage of rooting	No. of roots/ cutting	Length of roots/ cutting	No. of sprouts/ rooted cutting	Height of sprouts/ rooted cutting
Month	12016.93	11 49**	0.89ns	2.20*	7.30**
GRS	657.90	6.03**	0.44ns	2.40ns	1.40ns
Concentration	147.95	7.87**	0.14ns	3.18ns	0.95ns
Month x GRS	2148.18	3.54**	0.22ns	1.40ns	1.95**
Month x Concentration	373.19	3.20**	0.08ns	0.92ns	1.15ns
GRS x Concentration	82.70	0.20ns	0.17ns	0.16ns	0.48ns
Month x GRS x Concentration	2021.44	2.22**	0.26ns	0.84ns	0.93ns
Control vs. treated	54.84	0.21ns	0.12ns	0.18ns	0.08ns
Control vs. treated x month	1527.52	3.14**	0.27ns	0.88ns	1.62ns

** P = 0.01; * P = 0.05; ns = not significant

iii Bambusa balcooa

Since sufficient propagation material was not available detailed investigation was not carried out. Preliminary trials show that both culm and branch cuttings can be used for propagation. About 40% rooting was obtained in branch cuttings treated with IAA or coumarin and about 60% in culm cuttings with NAA 100ppm. Further study is required to find out the most favourable month of extraction of culm cuttings and treatments.

II PROPAGATION OF BAMBOO REEDS

i. *Ochlandra travancorica*

Percentage of rooting: The rooting response of cuttings in various treatments is given in Table 9. Rooting was observed only during the months of February to June. Control as well as cuttings treated with GRS rooted during this period. Maximum percentage of rooting obtained was 50. The analysis of variance of data is given in Table 10. Since the limitations mentioned for other species elsewhere are also applicable to ***O. travancorica.*** Treatments with maximum rooting percentage of 50 were considered promising. NAA 100 ppm in April, coumarin 10 ppm in March and April, and coumarin 100 ppm in May gave 50% rooting. Control also gave the same percentage in June but the response of treated cuttings was comparatively less during this month.

Number of sprouts: More sprouts were developed in cuttings treated with GRS than that of control (Fig. 10). The observed F-values for various effects are presented in Table 10. The three factor interaction (Month x GRS x concentration) was highly significant indicating that the performance of GRS at any level was not consistent over various months. Large number of treatment combinations were found as best groaps by DMRT and three of them with higest mean vahes are presented in Table 4. Maximum number of sprouts observed in control was 12-(May) whereas the most effective treatment (IAA 10 ppm in March) gave 21 sprouts per cutting.

Height of sprouts: A comparison of height of sprouts in control as well as treated cuttings is shown in Fig. 11. The analysis of variance of data on height of sprouts is given in Tabk 10. : The interaction between the three factors was significant at $p = 0.01$. indicating the inconsistent effect of the GRS and their levels over various months. The best groups of treatments shown by DMRT were IAA 100 ppm in April, and both coumarin 10ppm and NAA 100 ppm in April and May. While control sprouts had only a maximum height of 70 cm (June) it was 200 cm in treatment of IAA 100ppm in April.

Table 9. Percentage of rooting in bamboo reeds *Ochlandra travancorica* and *O. scriptorio* in response to various growth regulating substances

Treat-ments	Months	*Ochlandra travancorica* February	March	April	May	June*	*Ochlandra scriptoria* February	March	April	May	June*
Control		20	30	40	40	50	10	10	0	10	0
IAA$_{10}$		10	40	0	30	30	10	20	0	0	10
IAA$_{100}$		0	30	30	10	40	20	30	10	0	10
IBA$_{10}$		20	30	30	40	20	10	20	0	0	30
IBA$_{100}$		10	20	40	20	20	40	50	0	0	0
NAA$_{10}$		30	40	40	40	30	30	40	0	10	0
NAA$_{100}$		20	SO	50	20	10	30	40	10	0	0
Coumarin$_{10}$		30	50	50	40	10	0	10	0	20	0
Coumarin$_{100}$		20	40	40	50	20	0	10	0	0	0

* For both species no rooting was observed in any treatment from July to January

Table 10. Analysis of variance of the data on percentage of rooting, number and height of sprouts in bamboo reeds ***(Ochlandra travancorica*** and ***O. scriptoria)***

Source	*Ochlandra travancorica*			*Ochlandra sctiproria*		
	Percentage of rooting MSS	No. of sprouts F-values	Height of sprouts F-values	Percentage of rooting MSS	Number of sprouts F-values	Height of sprouts F-values
Month	1111.17	11.67**	5.74**	390.69	1.61ns	14.20**
GRS	71.04	5.20**	36.49**	117.02	2.41ns	6.76**
Concentration	45.02	0.55ns	0.05ns	59.10	0.51ns	1.44ns
Month x GRS	41.11	4.52**	2.65**	36.22	0.08ns	5.38**
Month x Concn.	33.22	2.19ns	10,33**	29.98	0.40ns	4.88**
Concn. x GRS	11.81	1.06ns	26.46**	6.61	0.18ns	**5.03****
Month x GRS x Concn.	15.72	3.51**	10.80**	18.35	0.22ns	2.64**
Control vs. treated	0.61	10.46**	85.31**	8.86	0.89ns	4.71**
Control vs. treated x month	192.46	1.93ns	0.17ns	53.70	1.43ns	0.87ns

** P = 0.01; * P = 0.05; ns not significant

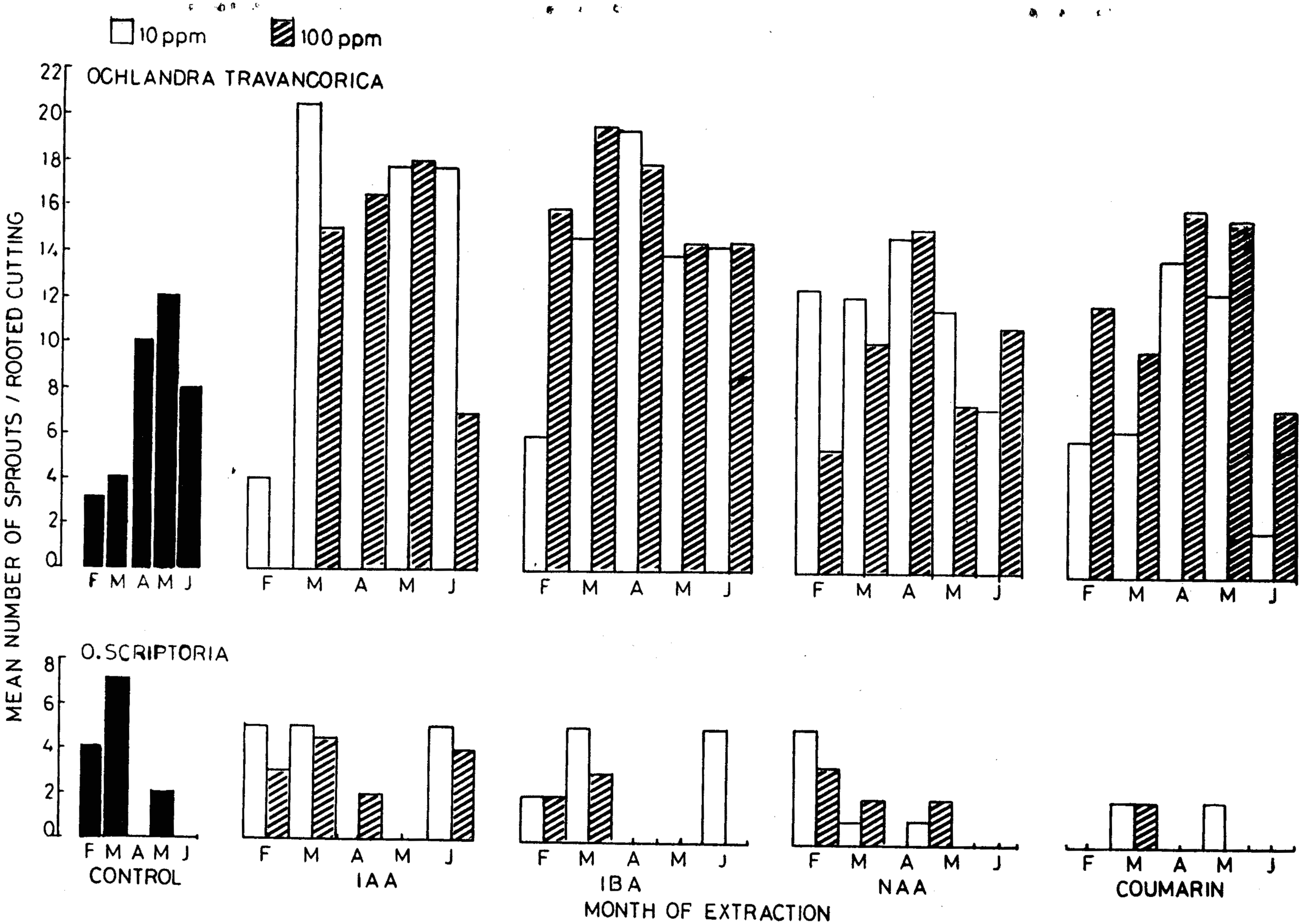


Fig. 10. Number of sprouts per rooted cutting of *O. travancorica* and *O. scriptoria* with various growth regulating substances.

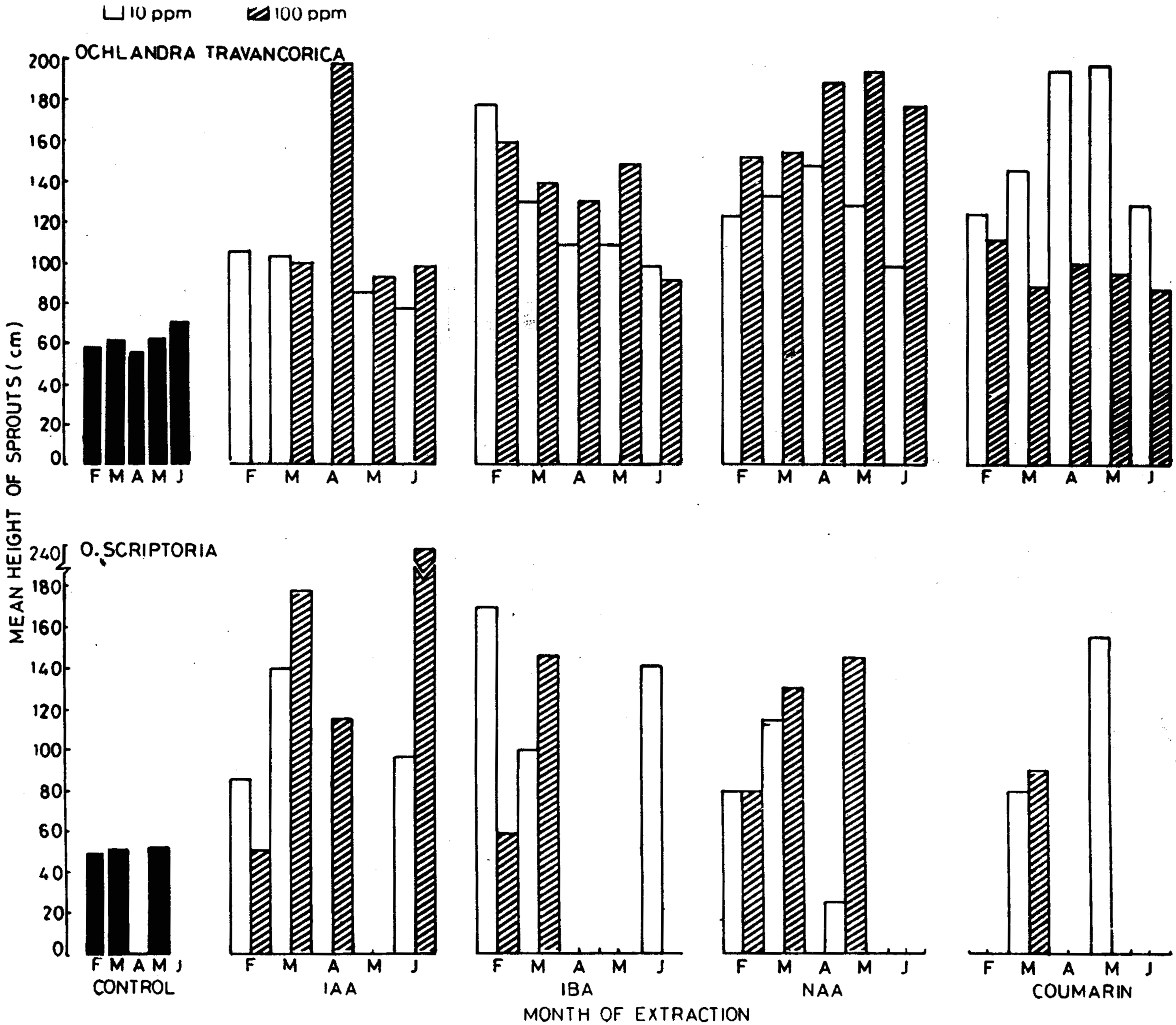


Fig. 11. Height of sprouts per rooted cutting of *O. travancorica* and *O. scriptoria* in response to various growth regulating substances.

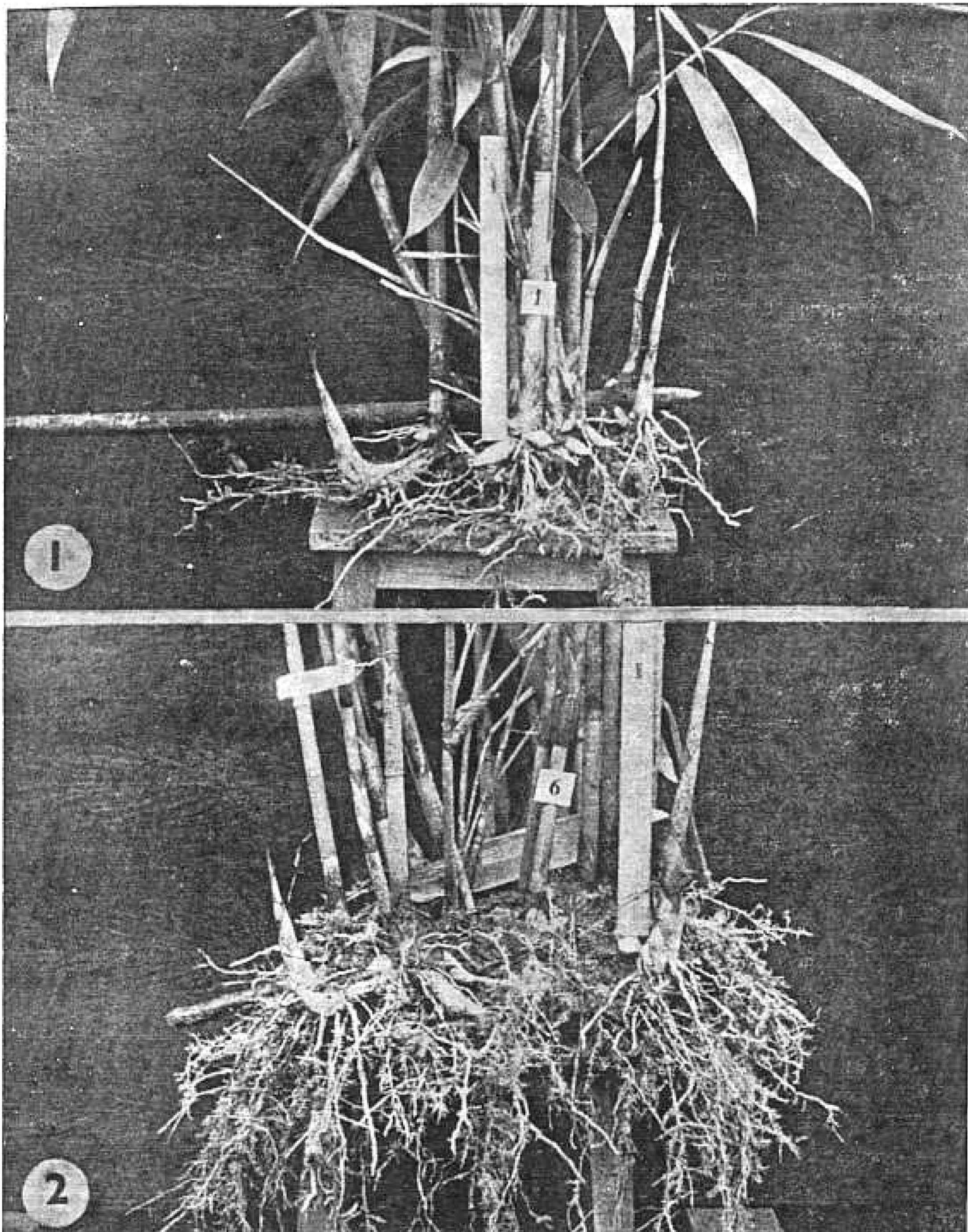


Plate IV Sprouting and rooting in culm cuttings of *Ochlandra travancorica*. 1, untreated cutting with fewer roots and sprouts; 2, cutting treated with NAA 100 ppm showing profuse roots and sprouts.

The selected treatments which gave maximum rooting and sprouting are presented in Table Although 50% rooting was obtained in control during June considering the vigour of sprouts treatment with GRS is desirable (Plate IV). Two treatment combinations, coumarin 10ppm and NAA 100 ppm in April gave both 50% rooting and increase in height of sprouts as compared to control. The same treatments were also among the large group of treatments which favoured increase in number of sprouts. Hence, either coumarin 10 ppm or NAA 100 ppm during April can be used for treating culm cuttings of ***O. travancoricu.***

ii. Ochlandra scriptoria

Percentage of rooting: The percentage of rooting in control as well as cuttings treated with GRS is given in Table 9. For analysis of variance the limitations mentioned earlier were applicable here also (Table 10). The treatment which gave highest percentage is selected as the best one. Maximum rooting obtained in control was only 10% and this was increased to 50% by a treatment of IBA 100 ppm in March. Although some rooting occurred during February to June the response was poor during April to June in all the treatments.

Number of sprouts: The number of sprouts were not influenced by any ***of*** the factors as revealed from Table 10. Although control gave maximum sprouts during March (Fig. 10). this was not significantly different from the treated cuttings.

Height of sprouts: The height of sprouts per rooted cuttings for various treatments are given in Fig. 11. The F-values (Table 10) reveal that the threefactor interaction is highly significant. Maximum height of sprouts was obtained in cuttings treated with IAA100 ppm in June followed by the same GRS in March. About three to four fold increase over control was observed in these treatments.

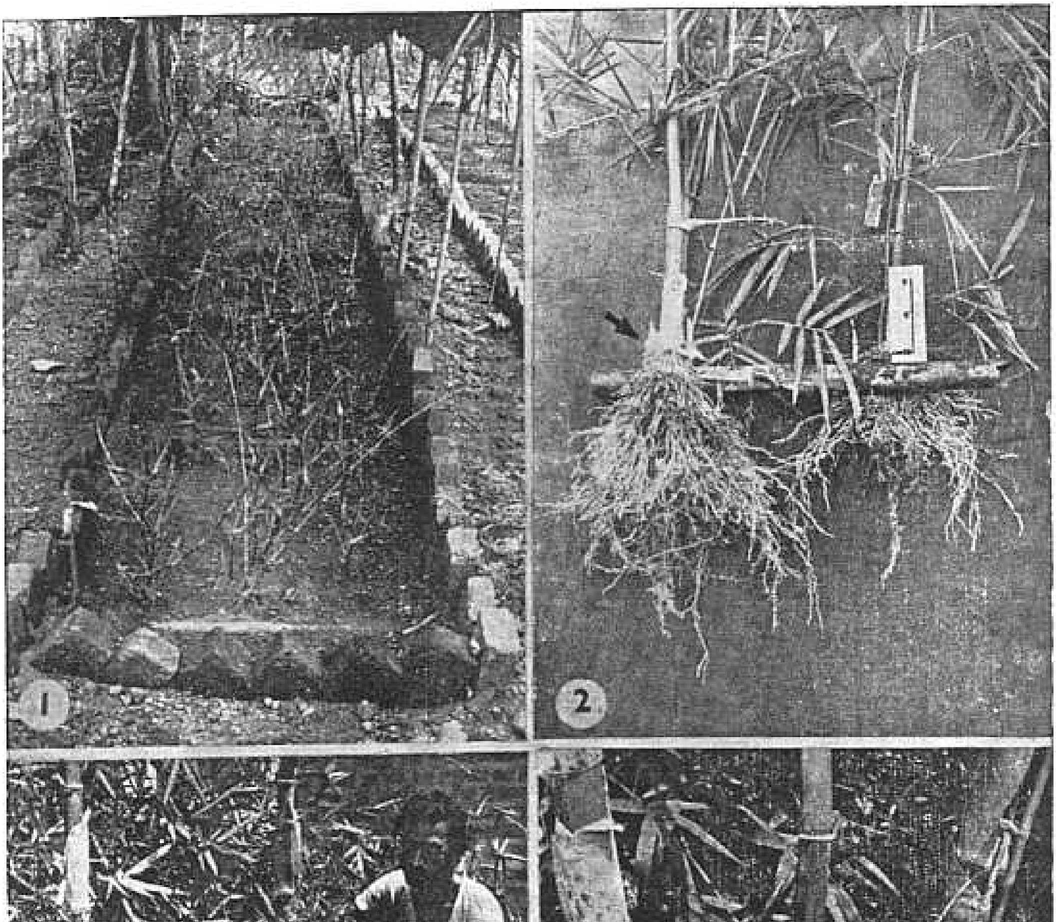
Treatments which gave maximum response for each character are presented in Table 4. Number of sprouts was not influenced by any of the factorial effects. None of the treatments gave both high percentage of rooting as well as maximum height of sprouts. However, the treatment which gave highest percentage of rooting (IBA 100 ppm in March) also increased the height of sprouts by 100 cm from that of control in the same month (Fig. 11). So this treatment can be selected for large-scale propagation of ***O. criptoria.***

DISCUSSION

Rooting was successfully induced in culm cuttings of bamboos ***(B. arundinacea, B. balcooa*** and ***D. strictus)*** and reeds ***(O. travancorica*** and ***O. scriptoria)*** by treating them with suitable growth regulating substances (GRS). Branch cuttings of ***B. arundinacea*** and ***B. balcooa*** and nodal bits of ***B. arundinacea*** also developed roots with the application of GRS. Furthermore, treatment prolonged the period of root induction over the control. Within a few weeks after planting of cuttings, sprouts emerged at the nodal region and after a month, slender roots appeared at the lower portion of the sprouts. When the sprouted cuttings failed to produce roots, the cuttings dried off slowly after a few weeks. Generally, rooted culm cuttings took about 3 to 6 months for profuse rooting and rhizome formation which was followed by the development of new culms (Plate V). Outplanted rooted cuttings of bamboos and reeds have established well and developed into new clumps within a period of 3 years (Plate VI).

One of the interesting observations which has emerged from this study is that, apart from auxins (IAA, IBA, NAA) coumarin, a phenol and boric acid, a weak inorganic acid can also promote rooting in bamboo cuttings, eventhough the effect of the latter was not significant. The effect of different GRS varied considerably with the month of extraction of cuttings and with different species. The most promising treatments for ***B. arundinacea*** were either IBA or NAA 100 ppm during March while it was only NAA 100 ppm during February or March for ***D. strictus.*** Cuttings of ***B. arundinacea*** and ***D. strictus*** treated with suitable GRS gave maximum rooting of 80% and 70% respectively, while the control lots gave only 40% and 50%. In ***Ochlandra scriptoria,*** where control responded with only 10% it was possible to enhance the rooting to 50% by treatment with IBA 100 ppm in March. However, in ***O. travancorica*** 50%rooting was obtained without any GRS treatment (Control) but cuttings treated with NAA 100 ppm and coumarin 10 ppm during April showed enhanced vigour. In general, higher concentration gave better response than lower one as also have been observed earlier (Bumarlong, 1977: Uchimura, 1977).

The rooting response of cutting is influenced by several external as well as internal factors. The latter may be playing a crucial role in promoting rooting in a particular month. In this regard the endogenous level of auxin is quite significant as it may promote or inhibit rooting by exogenous application of GRS. Our results conform with the earlier observations of Nanda (1970) who found that an auxin may stimulate rooting in one season, may be ineffective in the other and even inhibitory in yet another season depending on the endogenous level.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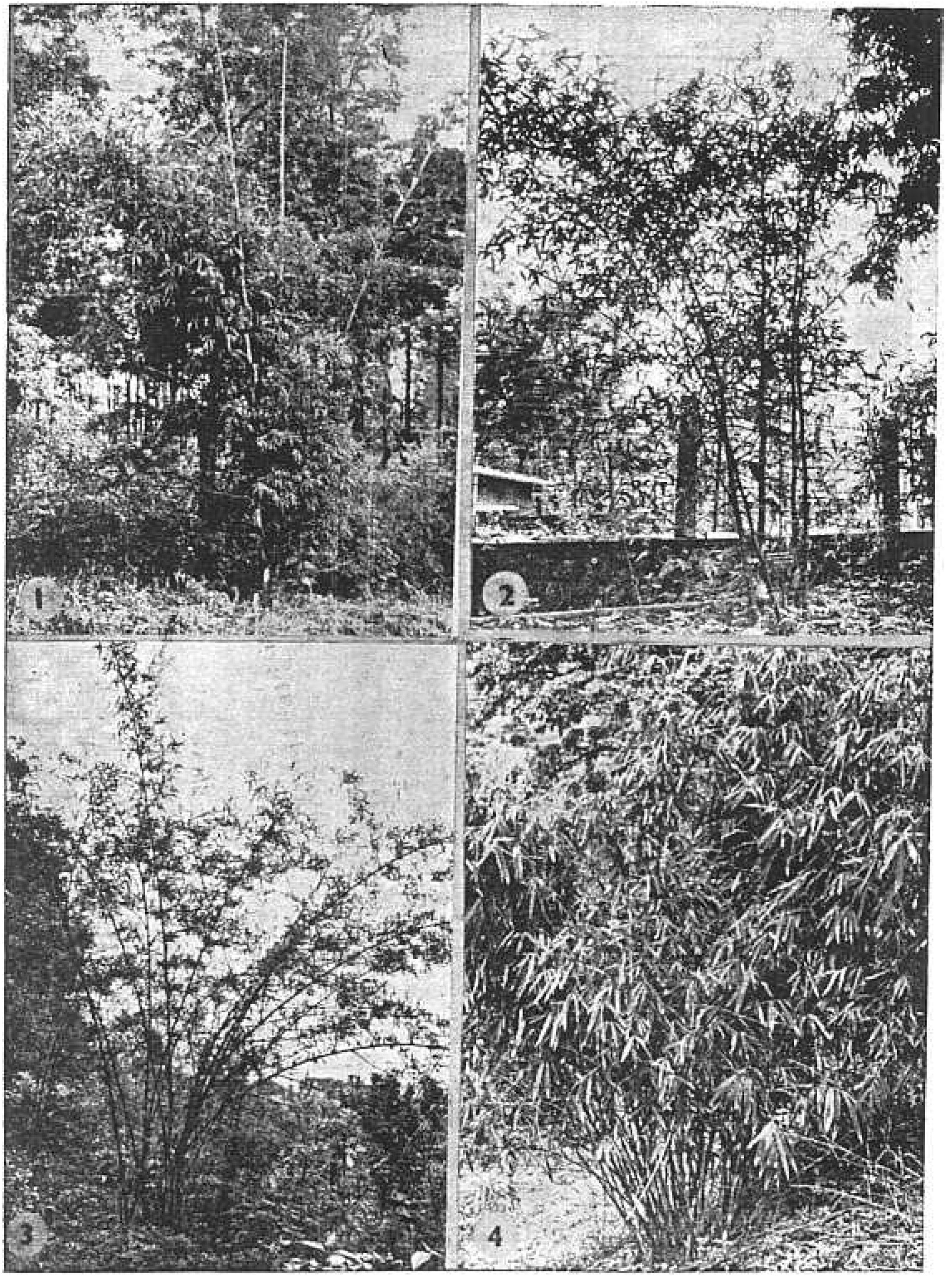

Plate VI. Field established cuttings of various bamboos and reed after three years. 1, *Bambusa arundinacea* (culm cutting); 2, *B. balcooa* (branch cutting); 3, *Dendrocalamus strictus* (culm cutting); 4, *Ochlandra scriptoria* (culm cutting).

Month of extraction of culm cuttings had a pronounced effect on rooting and sprouting responses. Generally, summer months (February-May) were found to be most favourable for extraction and treatment of both bamboos and reeds. A similar observation has been made by White (1947) and Gupta and Pattanath (1976) while studying the rooting behaviour of various bamboo species. In ***B. arundinacea*** GRS treated cuttings rooted throughout the year while in control rooting was restricted to 8-9 months. For ***D. strictus*** two peaks of high rooting were obtained in a year — one during the first half (February-March) and the other during the second half (August-September). No rooting occurred during July and December in control as well as in treated cuttings. The effect of months was more pronounced in reeds. Rooting occurred in control as well as in treated cuttings only during February to June both in ***O. travancorica*** and ***O. scriptoria.*** The rooting response of bamboos and reeds may have some bearing on the growth phase also. As already pointed out, generally, culm cuttings extracted during the month of active growth of parent clumps (June-August), responded with poor rooting. During the summer months (February-May) since the dormant buds of the culm become active, rooting response also increased. In the case of reeds apparently treatments with the GRS may not have been effective in breaking the dormancy of nodal buds of the culm cuttings during July to January when no rooting occurred at all.

Curiously the period of summer months during which maximum rooting in culm cuttings was obtained coincides with relatively higher temperature and low precipitation. During the trial period at Peechi it varied between 23^0c and 34°C while at Nilambur, between 27°C and 31^0c It appears that high temperature prevailing during this period promotes rooting more than the low temperature as the latter was also encountered during June to January when the rooting response was relatively poor. However, the converse appears to be true for the precipitation as indicated by maximum rooting which occurred during rainfall of 0-150 mm and minimum during 850-900 mm. From this it may be inferred that for obtaining good rooting response in bamboos and reeds high temperature and low precipitation are conducive. These findings conform with the earlier observation of Nanda (1970) that climatic factors like temperature, rainfall, humidity, etc. are known to have a direct bearing on the rooting response of cuttings.

The ‘cavity method’ which involves pouring the solution of GRS into the culm cavity, gave very good sprouting and rooting in cuttings. The penetration of GRS from the surface of the cavity may be better than through the cut end and basal portion as in ‘dip method’. It has been noted while giving preservative treatment for bamboos that penetration through cuticle is slow and needs longer time than through the inner side (Liese, 1982). He also observed that some penetration occurs through the nodes also when branches are cut off. The other advantage of 'cavity method' could be to keep the cuttings moistened and maintain certain degree of humidity which may be advantageous to promote rooting. This view gets support from the earlier observation of Abeels (1962). In the case of culm cuttings of ***D. strictus*** and branch cuttings of ***B. arundinacea*** and ***B. balcooa*** cavity method of treatment was not practical because of the lack of sufficient internodal cavity and hence only 'dip method' could be used.

Of the three types of propagation material used, culm cuttings had advantage over branch cuttings and nodal bits. Culm cuttings being large in size developed vigorous sprouts and rooted quickly which reduced the time required for rhizome formation (Plate 1111, 2, 4). It appears that the medium of planting has also some influence on rooting of ***B. arundinacea.*** Maximum percentage of rooting was observed in roil with IAA and in sand with IBA. The sprouts developed in cuttings planted in soil at Peechi were more vigorous than in sand used at Nilambur. Furthermore, starch content and level of various nutrients may also probably be influencing the rooting responses. This view gets support as seasonal variation in the amount of starch and N, P, K, Ca and Mg has observed in ***B. arundinacea*** and ***D. strictus*** by Joseph (1958) and Gupta and Pattanath (1976) respectively. Joseph (1958) found high amount of starch content in culm cuttings of ***B. arundinacea*** during February-March. Incidentally, our observations also show maximum rooting in treated cuttings of ***B.arundinacea*** during this period, which may aIso be due to the availability of stored starch for metabolic activities.

Of the two planting methods i. e., horizontal and vertical, tried for branch cuttings the former gave better sprouting and rooting (Plate 111 2, 3). The other advantage of the horizontal planting was to give equal opportunity to both the nodes to root and produce two propagules while in the vertical method only one node was available for rooting.

SUMMARY AND CONCLUSIONS

In the present study commercially important bamboos and bamboo reeds of Kerala viz. ***Bambusa orundinacea, Dendrocalamus strictus, Ochlandra travancorica, O. scriptoria*** and an introduced species ***Bambusa balcooa*** were successfully propagated vegetatively through culm cuttings. The rooting and sprouting responses were significantly enhanced by the application of one of the suitable growth regulating substances (GRS); indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA), coumarin or boric acid (BA). Although some cuttings rooted without GRS treatment the development of roots and sprouts was relatively poor. In all the species culm cuttings extracted and treated during summer months (February to May) gave better response than in other months. This could be correlated well with the high temperature and low precipitation prevailing during this period. The treatment to obtain maximum rooting and sprouting responses varied with species. IBA or NAA 100 ppm during March was the most promising treatment for ***B. arundinacea*** while NAA 100 ppm during February to March was the best for ***D. strictus.*** The most effective treatment(s) for ***O. scriptoria*** was IBA 100 ppm in March and for ***O. travancorica*** NAA 100 ppm or Coumarin 10 ppm in April.

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